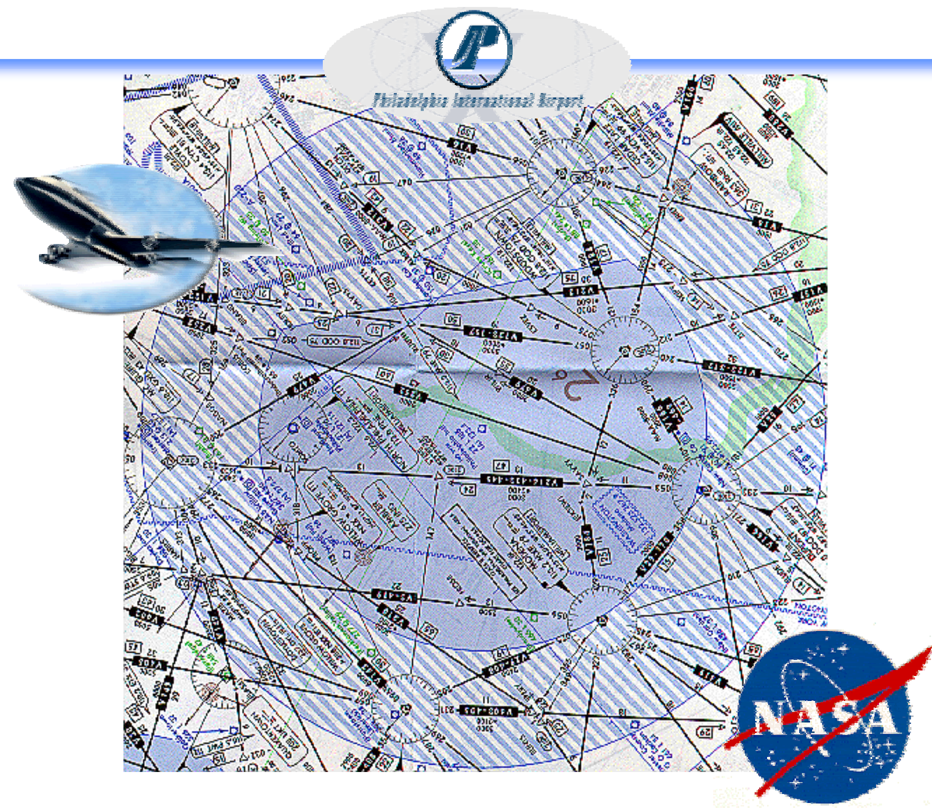
AATT NRA Task Order 16
Multifacility TMA
Requirements for Philadelphia Installation

Philadelphia TRACON Operations Document
~and~
Philadelphia TRACON Coordination/ Operational Procedural Document
Deliverable Items 2a & 2b



September 15, 1998

System Resources Corporation (SRC)
Federal Data Corporation (FDC)

TABLE OF CONTENTS

Multifacility TMA

INTRODUCTION

The Traffic Management Advisor is one of the decision support tools available in the Center/TRACON Automation System. The TMA tool is now in daily use at the FAA's Ft. Worth Center and assists in the planning and metering of traffic into the Dallas-Ft. Worth International Airport. The traffic demands at DFW are very high and the surrounding airspace configuration is relatively straightforward as compared with other locations in the National Airspace System. DFW is located in the center of the Ft. Worth Center area. Due to the airspace design, and the flows of traffic into the airport, it is designed with a corner post operation. The flows of traffic to the corner posts are fairly well balanced and traffic can be rerouted to correct any significant imbalance.

As a part of their continuing research, NASA determined that TMA should be looked at in a broader application. To foster this research, the Philadelphia International Airport and its surrounding airspace were chosen as a candidate for further application of TMA. The Philadelphia location has some unique attributes that are heretofore not experienced by TMA. The Philadelphia environment is among the most challenging of any faced by TMA. Among the complexities that impact the introduction of TMA into Philadelphia are:

- The PHL TRACON airspace operation is very complex. Airspace constraints imposed by geography and the proximity of adjacent ATC facilities must be considered. For example, to the east, McGuire AFB is located in such close proximity that its designated airspace (as described in a Letter of Agreement between PHL, WRI, New York ARTCC and New York TRACON) impacts on the final approach path of aircraft landing to the west at PHL.

- Although New York ARTCC is the host for PHL TRACON, arrivals also come from Washington ARTCC, New York TRACON, McGuire TRACON, Atlantic City TRACON, Dover AFB, Baltimore TRACON, Harrisburg TRACON, Reading Tower and Allentown Tower.

- There is a heavy volume of both commuter and general aviation traffic, which provides a mix of high and low altitude traffic. As a result, it will be necessary to investigate the delay allocation logic between the high (above FL240) and low altitude controllers used in the Fort Worth tests. The current PHL TRACON procedures are set up for fast track and slow track aircraft. Slow track handoffs (props) come from tower/en route facilities, while the fast track aircraft (turbojets) come from the centers.

- Coordination is required with two Centers versus one at Dallas/Ft. Worth.

In addition to the complex inter-facility coordination, controllers at PHL have designed and continuously improved on intra-facility procedures which rival in complexity and efficiency any found in the NAS. The introduction of TMA into PHL will present a significant challenge. This report reviews the internal procedures and the interactions with surrounding terminal and en route facilities as the basis for possible modifications to operational and/or algorithmic features of TMA.

This task requires four separate items to be delivered . This document represents the completion of deliverable Item 2. The remaining items will use this document as the basis for the development of the TMA candidate concepts and the implementation planning necessary for the integration of TMA into the Philadelphia area.

PHILADELPHIA INTERNATIONAL TOWER/TRACON

GENERAL DISCRIPTION

The Airport Traffic Control Tower and Terminal Radar Approach Control (TRACON) room at Philadelphia International Airport (PHL) are located on the south side of the field. It is an "up & down" facility where controllers rotate between the tower cab and the radar room on a regular basis.

There are a potential total of 16 positions of operation in the TRACON and 7 in the tower cab. The latter includes: 2 local control (LC) positions (East & West), 2 assistant local control (ALC) positions (East & West), 1 ground control (GC) position, 1 flight data (FD) position, and 1 clearance delivery (CD) position. During light traffic periods many of these positions are combined (e.g., CD with FD, ALC with LC, and LC2 with LC1).

In the TRACON, there are 10 radar positions: Arrival North (AR1) and Arrival South (AR2), Departure North (DR1) and Departure South (DR2), 2 Final Vector positions, and 4 Satellite positions (Yardley, Woodstown, DuPont, & Pottstown). There are 4 handoff (HO) positions that directly support the radar positions during heavy traffic conditions. There are also 2 FD positions in the TRACON. These radar positions are often combined during light traffic to 1 final vector controller, 2 arrival controllers, 1 departure controller, and 2 satellite controllers.

There is ordinarily one supervisor in the cab and one in the TRACON. Depending on traffic demand, the traffic management coordinator (TMC) position is staffed in either the cab or TRACON, or both.

Authorized staffing at PHL is 79 controllers. There are currently 66 controllers assigned to the facility, all full performance level (FPL). There are no developmental controllers at this time. There are normally 2 supervisors on duty during a day shift (7 AM to 3 PM) and 2 on an evening shift (3 PM to 11 PM) and 1 TMC for each of these shifts. On occasion, a third supervisor and/or a second TMC are on duty.

There are 2 east-west runways, 9/27 left and right, and a single north-south runway, 17/35 that serves as a reliever runway for propeller driven aircraft. The prevailing winds dictate landings and takeoffs to the west 80% of the year. The ideal arrival-departure configuration is landing runway 27 right (27R) and departing 27 left (27L), in conjunction with landing and departing runway 17. Ironically, the main instrument landing runway (Category III) is runway 9R.

The facility traffic count for 1997 was approximately 629,000 radar operations with 474,000 landings and takeoffs at PHL. The TRACON has responsibility for IFR operations at 26 satellite airports in the PHL area, including Trenton, New Jersey; Wilmington, Delaware; and North Philadelphia Airport.

Arriving and departing instrument operations at the satellite airports do not directly impact arrivals and departures at PHL. That is, it is not necessary to shut down any arrival or departure operation at PHL in order to arrive or depart from one of these airports.

Consistent with operations at other major northeast facilities, holding is a common practice at PHL. It is routine during periodic rushes of arrival traffic (on a daily basis, several days each week) and is employed whenever the arrival controller's judgement dictates.

AIRSPACE

PHL is located in the highly complex and congested northeast corridor of the US, in close proximity to such major air carrier airports as Baltimore, Washington, Dulles, and the New York complex of LaGuardia, Newark, and Kennedy. Arrival and departure flows between these airports and traffic flow between Ronald Reagan Washington National and Logan Boston airports directly impact the PHL operation. This location is further impacted by the boundary of New York ARTCC (ZNY) and Washington ARTCC (ZDC), which crosses PHL airspace in a general southwest to northeast direction.

Generally, the airspace delegated to PHL and the surrounding approach control facilities is 10000 feet and below. There are some areas in which differing altitudes are specified to accommodate unique and special circumstances. The airspace delegated to PHL also includes the holding pattern airspace for the four primary arrival fixes to accommodate holding by the TRACON.

FACILITY INTERFACES

Due to the constraints levied by the en route automation system, HOST, the PHL airport and the delegated approach control airspace must be described in only one en route adaptation database. Based on the location of the airport it is therefore described in the ZNY adaptation database. This constraint requires that the ZNY automation system be the Host and the ZDC automation system be the Non-Host. This configuration does not inhibit the transfer of data, but may influence the handling of the data.. The processing and passing of flight and radar data is significantly impacted by this arrangement. It would be very difficult, if not impossible, to modify the en route automation software to change this processing requirement.

In addition to the automation interfaces with the ZNY and ZDC, PHL is virtually surrounded by other ATC facilities. These facilities are of varying types; civil (ARTS II, ART III and non-ARTS) and military. The ARTS II, ARTS III, and some military locations have an automated interface through the Host – Non-Host environment.

With regard to the collection of data on arrivals into PHL, the fact that the facility is fed arrivals from two en route facilities and several tower en route facilities presents a perplexing situation. No one system, either ZNY or ZDC, has the ability to determine what the total demand is at all the arrival gates. The data for BUNTS and MAZIE is resident in the New York system and the data for TERRI and Cedar Lake (VCN) is resident in the Washington system. Data on the tower en route arrivals are not available in either system.

A significant amount of traffic in the northeast corridor flies at approach control altitudes and are controlled by the terminal facilities. The flight plan and radar data on this type of traffic are not available from the en route automation system. Some of the approach control facilities that are juxtaposed to PHL are Dover AFB, McGuire AFB, Harrisburg, Baltimore, Atlantic City, and

New York TRACON. Each of these facilities, in addition to other locations have defined routes and altitudes to be used for traffic originating or flying through their airspace into PHL airspace. If the flight is not landing at an airport within the PHL airspace, there are defined routes and altitudes that must be assigned for aircraft departing their airspace. These aircraft are handled like a PHL departure with an assigned altitude within the approach control airspace.

Flight plan data is forwarded to PHL Approach by an automated interface from ZNY. This data includes arrivals, departures, and tower en route data:

Arrivals to PHL, arrivals to satellite airports within approach control airspace, and arrivals to airports outside the airspace require PHL to control the aircraft. PHL arrivals and satellite arrivals are handled as routine arrivals. Arrivals to airports outside their airspace are considered tower en route over-flights. They are handled like PHL arrivals and are handed off to the adjacent facility. An example of this would be a McGuire arrival from the west or a Dover arrival from the northwest. Data on these flights are maintained in the en route system and are normally updated and tracked by the en route system. The flight plan and radar data are also passed to the Enhanced Traffic Management System (ETMS) and Aircraft Situation Display (ASD) Systems.

Tower en route data are passed to PHL; however, it is not retained by the en route system. Once the flight plan is analyzed by the en route system and determined to be a tower en route flight by virtue of route and/or altitude, it is forwarded to PHL, in both Flight Data Input/Output and ARTS data formats. Flight plans are retained in the en route system until the flight departs at which time the departure time is forwarded to appropriate facilities and then the flight plan data is discarded. The flight plan and tracking data are passed to the ASD system by the terminal systems to assist the displaying flow control data.

The automated handoff process is available for both arrival traffic and tower en route flights. For the arrival traffic coming from either ZNY or ZDC, the controller or system initiates the handoff prior to the aircraft reaching the approach gate. The transfer is completed when the PHL controller accepts the handoff. Both the en route and the terminal computers execute the target correlation algorithms and the position of the targets must agree in both systems.

Tower en route data and handoffs are handled differently. This is a part of the Host – Non-Host environment. If the flight is within airspace defined as an approach control within the ZNY airspace, it falls into the Host category. The en route computer receives the flight plan and handoff data from the originating approach control and passes it to the appropriate adjacent facility. The information is not analyzed or processed by the en route system, it is merely forwarded. In the case of an approach control airspace outside the ZNY airspace but adjacent to PHL, it falls into the Non-Host category. The flight plan and handoff data are received by the Non-Host en route system. The data stream is addressed by the originating facility. The message is forwarded by the Non-Host system to the Host system, which then forwards it to PHL. Neither en route system analyzes, processes, or retains the data; again it merely acts as a forwarding agent.

PHILADELPHIA ARRIVAL PROCEDURES

For details on airspace specific information described below refer to the navigational aid charts provided in the attachments.

The basic arrival flow into the PHL airspace from ZNY and ZDC is over four feeder fixes. This permits PHL to regulate and sequence arriving aircraft in a manner that maximizes the airport arrival rate according to runway configuration and weather conditions. These procedures are subject to Letters of Agreement (LOA) (See Attachments) between the facilities, spelling out specific nuances of the operational and procedural issues.

The TRACON radar positions are configured to handle arrivals from ZNY to the Arrival North position and arrivals from ZDC to the Arrival South position. These two radar controllers sequence arriving traffic and feed it to the Final Vector controller (or controllers if both Final Vector positions are manned- not a common occurrence). The Final Vector controller is responsible for spacing on the final approach course and for controlling missed approaches.

Both runway configuration and weather conditions can significantly influence the airport arrival rate at PHL. For example, the most efficient runway configuration, the one that produces the best arrival rate, is landing runway 27R - departing runway 27L, and landing and departing runway 17. This configuration is supported by the annual prevailing wind conditions approximately 60% of the time. In the fall of the year, prevailing winds are from the northwest and require more utilization of runway 35 with runways 27R and 27L. Facility staff estimates that runways 27R and 27L are used 80% of the time.

During periods of low visibility, wind conditions permitting, runway 9R is the primary landing runway and runway 9L is used for departures. Runway 17 has an ILS associated with it and is used for props whenever possible. There is no precision approach to runway 35.

Table 1 shows all the current airport runway operational configurations. The figure on page 8A illustrates the nominal paths from the four feeder fixes to runway 27R. Other nominal paths for other runway configurations are illustrated in the attachments.

The nominal paths for propeller aircraft to runway 17/35 are not illustrated because there is no currently defined standard routing. This aspect of the operation will be considered as analysis of TMA operations continues. The prop traffic that can maintain 210 IAS or better is usually kept in the flow of jet traffic to the main east west runways. Controllers exercise a great deal of flexibility in mixing these props and jets and in moving props over to runway 17/35. As a result a nominal path to runway 17/35 will have to be defined to introduce TMA into this facility.

Table 1: Airport Runway Operational Configurations for PHL

	27L	27R	9L	9R	17	35
Config 1	D	A			A/D	
Config 2	D	A				A/D
Config 3			D	A	A/D	
Config 4			D	A		A/D

D = Departure runway; A = Arrival runway; A/D = Arrival and Departure runway

If runway 17 is in use for props, these aircraft are controlled by the Pottstown Satellite radar controller and sequenced with runway 27L/27R traffic using the Converging Runway Display Aid (CRDA) function. If runway 35 is in use, the Woodstown Satellite radar controller controls that traffic in a similar way. The runway 35 operation is less efficient because the final approach course crosses the arrival or departure end of the main east-west runways. In this situation, there is a subtle impact when 27R is used for landing and 27L is used for departures because the controllers are used to using the left runway for an escape route when there is an overtake situation on the right runway by side stepping the overtaking aircraft from the right side to the left side and avoiding a go around. Traffic landing on runway 35 makes this difficult at best. When runway 17 is in use, the aircraft are cleared to land, hold short of runway 9L/27R. This is, in effect, operating the runways on a non-interfering basis. Therein lies the key to the greater arrival rate using runway 17 and runways 27L/R.

It is expected that the aircraft landing and departing runway 17/35 will be transparent to the TMA stream for the primary east west runways in the current operation. This will require further analysis as we progress in the study of introducing TMA to PHL.

In general, turbojet traffic is routed over the four fixes, BUNTS, MAZIE, TERRI and VCN. Propeller traffic is routed over these same fixes and DuPont (DQO) at the same or lower altitudes. Propeller traffic from the west not capable of maintaining 210 knots indicated airspeed (IAS) is routed through Harrisburg Approach Control. Prop traffic routed over VCN will be routed through Atlantic City Approach Control.

Overall, the PHL arrival traffic from the west, northwest and north follows two general tracks through ZNY:

BUNTS traffic is fed through ZNY Area D via the Phillipsburg (PSB) Sector and into ZNY Area A via the Middletown (MDT) sector and Lancaster (LRP) sector. This traffic enters ZNY at flight level 250 (FL250) from Cleveland ARTCC (ZOB) and is required to cross BUNTS at 8000 feet in accordance with the PHL/ZNY LOA. The traffic is also slowed to 250 knots as it approaches BUNTS. If holding is initiated by PHL (this is the norm), the PHL controller makes the call regarding which aircraft ZNY will put on the PHL frequency.

MAZIE traffic is usually routed through ZNY Area D via the Pottstown (PTW) sector and crosses MAZIE at 11000 feet. If holding is initiated, traffic will hold at 11000 feet through 14000 feet at SPUDS intersection, 17 miles northwest of MAZIE where there is a published holding pattern. All aircraft slow to 250 knots as they reach 10000 feet unless slowed by the controllers for spacing purposes or to enter holding. There is relatively little holding for traffic routed over MAZIE. The bulk of ZNY holding of PHL traffic is at BUNTS. We were unable to get statistics on this, but anecdotal accounts at both facilities support this observation. The ASD data also indicate the higher traffic flow over BUNTS.

Radar service is terminated by ZNY as the aircraft become established in all of the holding patterns for PHL. The PHL controllers then reestablish radar contact as they pull aircraft from the holding patterns. Holding at BUNTS is at 8000 feet through 14000 feet. Additional holding of BUNTS traffic by ZNY is at Lancaster (LRP), even though there is no published holding pattern airspace at LRP. If these two fixes are at full capacity, ZOB would have to hold in their airspace. The Middletown (MDT) controller makes the sequencing determination regarding traffic going to BUNTS.

The ZNY Traffic Management Unit (TMU) gets involved as traffic volume increases and uses ASD data as well as local knowledge and awareness in their decision making. If the ZNY controllers notice any slow reaction to handoffs by PHL controllers, they treat this as an indication that PHL will institute holding soon. This kind of intuitive experience is an essential ingredient in the controller environment. If they fail to make use of it, the element of surprise in a sudden shutdown of arrival traffic over any fix can create an extremely challenging situation as controllers look for places to put aircraft already committed to their sectors. At the same time, if ZNY TMU and sector controllers determine the need for some kind of flow restrictions due to situations apparent to them, the final decision rests in the hands of the Air Traffic Control System Command Center (ATCSCC).

ZNY ARRIVALS

The bulk of traffic arriving from the ZNY into the PHL area comes over BUNTS. Turbojet aircraft are to cross BUNTS at 8000 feet. Props capable of maintaining 210 IAS cross BUNTS at 7000 feet. Traffic arriving over less busy MAZIE (PHL turbojets only) will cross MAZIE at 11,000 feet. ZNY will insure that all aircraft cross the appropriate transfer point at 250 IAS or less.

There is published holding pattern airspace at BUNTS and SPUDS (MAZIE traffic). These holding patterns were recently revised by ZNY to provide adequate separation for PHL departures routed over Pottstown (PTW) to be clear of the holding pattern airspace whenever simultaneous holding is taking place at BUNTS and MAZIE. The PHL staff does not believe there is adequate separation and will hold PTW departures on the ground whenever there is such simultaneous holding. In any case, simultaneous holding is rare because the traffic over MAZIE is relatively light.

Whenever there is holding at BUNTS, several times each day, ZNY has to look for places to hold subsequent traffic because they lack airspace beyond holding at Harrisburg VOR and are forced to back up traffic into ZOB airspace in a ripple effect. Holding up to 14,000 feet at BUNTS mitigates this. ZNY can hold up to 13,000 feet at SPUDS.

When there is holding at BUNTS, ZNY terminates radar service on aircraft entering the holding pattern. When holding at SPUDS, ZNY retains control until PHL advises that the aircraft can be recleared to PHL via MAZIE.

ZDC ARRIVALS

The PHL arrival traffic from ZDC is handled from two tracks feeding the two arrival fixes, Cedar Lake (VCN) and the TERRI Intersection.

Traffic to VCN is generally from the East Coast of Florida and other locations on the eastern-most coast. Traffic over Charlestown (CHS) and the overwater AR routes proceed over Norfolk (ORF) to Snow Hill (SWL) and Sea Isle (SIE) descending to approach control altitudes. At SIE, they turn northbound and proceed to VCN descending to 9000 ft. and are handed off to PHL. Traffic approaching from this area inbound to PHL satellites is handled the same as a PHL arrival. Traffic from the northeast and arrivals from deep-water locations are routed via VCN and are merged with the arrival traffic from the south as described earlier. Holding at the lower altitudes is done by PHL.

Traffic to TERRI intersection originates from the West Coast of Florida and the southwest US. On an arc from Savannah (SAV) to Beckley, W.Va. (BKW), traffic merges at Flat Rock (FAK), Gordonsville (GVE), and lastly Nottingham/Brooke (OTT/BRV) then proceeds to TERRI descending to approach control altitude of 10000 ft. When initiated by the ATCSCC some traffic from the west is routed via BKW and becomes part of the TERRI flow when traffic or weather in ZOB dictates. Satellite arrival traffic is handled the same manner as a PHL arrival.

ADJACENT FACILITY TRAFFIC

The location of the PHL Airport in the complex northeast corridor has a negative impact on the movement of traffic both in and out of PHL. Some examples of these influences are as follows:

- Departure traffic from the metropolitan New York Airports to Dulles (IAD) forces the PHL arrivals from the west to lower altitudes at Harrisburg (HAR) and LRP.

- Arrivals from the south and southwest, over the Washington and Baltimore area are kept high to over fly the Baltimore Approach Control airspace.

- Arrival to PHL from the New England area; Boston (BOS), Manchester (MHT), Providence (PVD), etc., are routed over water to the east of New York metropolitan area to a point east of Atlantic City (ACY) and then turned toward VCN and merged with the arrival traffic from the south.

- When weather affects an adjacent facility, the impact on the PHL operation is also affected. Thunderstorms can shut down arrivals at other airports and traffic into PHL arrival will be held at outlying fixes due to holding for other airports. Generally, when thunderstorms impact any airspace in the New York or Washington area, the entire northeast corridor is impacted.

AUTOMATION AND FLOW CONTROL TOOLS

The standard set of flow control tools is available for the PHL operation. The facility has a small traffic management unit in the TRACON, which is staffed on the day and evening shifts with one or two specialists. The unit is equipped with an ASD display, ETMS display, and communication capability with the ATCSCC in Herndon, Virginia, and other facilities. The specialist uses the ETMS and the ASD to monitor the flow of arrival traffic anticipated into PHL. There is a TMC workstation in the TRACON, but it is located in a position that makes it difficult to operate during busy traffic periods. Normally, the TMC stays in the tower cab if there are heavy departures and light arrivals, but goes into the TRACON during heavy arrival flows with light departures. Ideally, if there are 2 TMCs on duty, one is in the cab, the other in the TRACON during heavy arrival and departure flows. The TRACON TMC is the TMIC (in charge). In the circumstance of only one TMC with heavy arrival and departure flows, it is the option of the TMC to choose where to function most efficiently. Most stay in the TRACON during such periods.

While PHL is officially designated as a Managed Arrival Reservoir System (MARS) facility, this designation is not a significant part of the current operation. In reality, the only benefit derived from this designation is the establishment of the published holding pattern airspace at the four feeder fixes serving the airport. MARS technically permits certain flow control programs (e.g., arrival delay) to include a few additional aircraft above the engineered airport acceptance rate. The purpose of these additional aircraft is to insure that adequate pressure is maintained on the arrival flow to maximize the acceptance rate.

Regardless of MARS Implementation, PHL keeps the aircraft coming until they become saturated, at which point holding begins. This occurs several times each day, not just during flow control programs. There are no routine flow control restrictions in place for PHL traffic (e.g., daily scheduled miles-in-trail restrictions). However, MIT restrictions may be used from time to time, as traffic dictates (though this is often impeded by ATSCC). The consensus among the three involved facilities is that there is sufficient pressure on the arrival rate to make best use of the airport capacity.

FUTURE OPERATIONS

The current trend by short haul carriers towards regional jets (over propeller aircraft) will have an adverse impact on the current runway configurations because it will become more difficult to use the short runway (17/35) with these aircraft. No configuration changes are currently being considered to handle this trend.

Current operations will be improved slightly by the introduction of runway 8/26 at the end of 1999 (layout of 8/26 in attachments). The introduction of the new runway is subject to several limitations because of its short length (5000 feet) and close proximity to the airport terminal building. This latter consideration will mandate departures only from runway 8 and arrivals only on runway 26. Runway 26 will have an ILS associated with it. The ILS will have a 2-_ degree offset to clear obstructions. PHL staff believes the best results of the introduction of the new runway will be its availability as an alternate runway for props. They do not see any change in the traffic flows or any significant increase in the airport acceptance rate.

COMMENTS and OBSERVATIONS

While it was difficult for the team to initially see similarities between Dallas/Ft. Worth (DFW) and PHL, it soon became apparent there are many common elements that lend themselves to the introduction of TMA into the PHL environment. Among these are the four feeder fixes used to control arrivals into the TRACON area, the predictable and periodic heavy “pushes” of aircraft that test the arrival capacity of the airport, the multi-runway configurations, and the presence of a major air carrier hub operation.

The ARTCC/TRACON operations were difficult to separate from the ARTCC/TRACON coordination procedures at these three facilities. The lack of formal coordination between the ARTCCs and the TRACON presents many potential issues. The coordination between facilities was basically ad hoc and seemed dependent on TMU and TMC staffing on a given shift. The ZNY TMU seemed to be more proactive then the ZDC TMU. This could be due to the volume of traffic generated by the respective facilities. It will be essential to formalize such coordination in any attempt to introduce TMA to these facilities. In addition, the challenge of a lack of a common automation database for arrivals coming from two centers seems to be a real obstacle to be overcome.

In all, it seems clear that PHL is a viable candidate for TMA. All three facilities were open minded and interested. They will welcome any assistance in dealing with a difficult and challenging traffic situation on a daily basis.

Attachments

LIST OF ATTACHMENTS

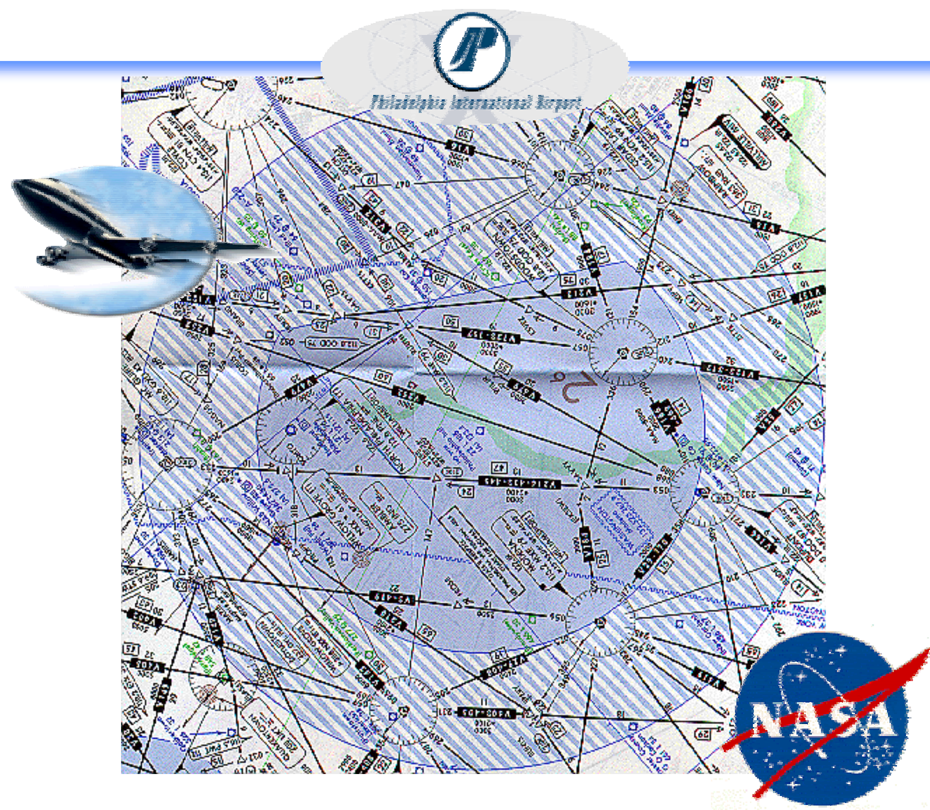
AATT NRA Task Order 16
Multifacility TMA
Requirements for Philadelphia Installation

Candidate Operational Concepts and System Modifications

~and~

Work Plan and Staffing Requirements

Deliverable Items 3 & 4



January 15, 1999

System Resources Corporation (SRC)
Federal Data Corporation (FDC)

TABLE OF CONTENTS

1.0 Background

As part of a collaborative program between NASA's Ames Research Center and the Federal Aviation Administration (FAA), NASA is examining approaches to improve the capacity and efficiency of the U.S. air traffic control (ATC) system. To this end, NASA Ames initiated a study into the viability of installing a traffic-scheduling tool, the Traffic Management Advisor (TMA), into the heavily traveled and complex Northeast corridor of the United States. This decision support tool is an element of the Center/TRACON Automation System (CTAS) suite of tools currently in advanced stages of development at several FAA Air Route Traffic Control Centers (ARTCCs), including Fort Worth ARTCC. TMA, at the Fort Worth ARTCC, has been accepted by the facility as a useful tool for controllers in scheduling heavy flows of air traffic from the en route control facility to the responsible terminal radar approach control (TRACON) facility.

This study, issued as Task Order 16 of NASA's Advanced Air Transportation Technologies NRA contract, was created to develop an initial understanding of Philadelphia's International Airport (PHL) and the associated TRACON and ARTCC facilities that support PHL arrival traffic. Specifically, the study was to perform an analysis of TRACON and ARTCC airspace configuration and operations in support of PHL arrival traffic and to propose candidate operational concepts, algorithmic modifications, adaptation requirements, and a development work plan for the implementation of TMA for PHL.

System Resources Corporation (SRC) and its team member Federal Data Corporation (FDC) assembled a team of engineers and ATC operations experts to perform the required operations analyses and to develop the candidate operational concepts and system modifications. This team consisted primarily of: Robert A. Vivona (SRC), a senior systems engineer with experience in developing advanced automation system concepts for NASA; Edmund Spring (FDC), a former manager for PHL TRACON/Tower, Washington ARTCC and the Eastern Region Air Traffic Control Division; Gordon Heritage (FDC), a former controller (en route), Data Systems Officer (en route and terminal) and Assistant Manager for Quality Assurance at Washington ARTCC; and Tony Serino (SRC), a former controller and air traffic manager with experience in Tower, TRACON and ARTCC facilities throughout the Northeast. This team performed initial site visits with the three major facilities involved in delivering traffic to PHL: PHL TRACON, New York ARTCC, and Washington ARTCC. During these visits, the team interviewed operations specialists, traffic management coordinators, and air traffic controllers to gain an understanding of the operational complexities and therefore, the potential opportunities for achieving benefits by implementing TMA within this environment. Site visits to Fort Worth ARTCC and Dallas TRACON were performed to gain insight into the current use of TMA at these facilities. The team used the knowledge gained from these visits to develop the operations analyses and system concepts developed for the deliverables of this task order.

The analysis of TRACON and ARTCC operations was previously delivered by the SRC team to NASA as Deliverable Item 2 in September of 1998. This document represents both the final descriptions of candidate operational concepts, algorithmic modifications, and adaptation requirements (Deliverable Item 3) and a work plan for the development of TMA (Deliverable Item 4) as outlined in the original statement of work. The elements of the operations analysis pertinent to discussions within this document have been taken from Deliverable Item 2 and incorporated in this document for easy reference.

Within the definition of new operational concepts and required TMA modifications, careful consideration of all known FAA system infrastructure enhancements and other external changes that could affect the implementation of TMA for PHL were addressed. This information presented is meant to support follow-on efforts in the conduct of implementation analyses, potential benefits studies, and prototype system development.

Deliverable Item 3

Candidate Operational Concepts and System Modifications

2.0 Introduction

PHL was selected as a potential site for the application of TMA primarily because it is a busy Level V terminal that, as an expanding hub for a major U.S. air carrier (US Airways) could gain significant benefits from TMA scheduling. PHL was also selected because of its unique location. The airport and terminal area are located almost directly on the boundary of New York ARTCC (ZNY) and Washington ARTCC (ZDC). Both of these ARTCC facilities feed arrival traffic to the TRACON. Located within the heavily traveled Northeast corridor, where several other major terminal facilities are within close proximity, the PHL arrival streams in both ZNY and ZDC impact and are impacted by the arrival/departure streams for these other facilities. It is expected that identifying and addressing issues that impact new concepts for the application of TMA to PHL will develop the foundation for solutions to the application of TMA to even more complex airspace configurations. This will hopefully support the expansion of TMA applicability to even more facilities within the U.S.

The PHL Tower/TRACON is a Level V terminal facility. This is the FAA's highest classification level for a terminal ATC facility. It confirms a level of traffic complexity and volume requiring the highest level of ATC personnel and procedures. It is facilities of this level that the FAA traditionally has first added new technology, such as radar, automation and related enhancements, at the earliest opportunity. In the case of PHL, the facility's geographical location and proximity to other major traffic terminals such as Baltimore Washington International Airport (BWI), Dulles International Airport (IAD), and Newark International Airport (EWR) with their attendant arrival and departure traffic flows compounds this complexity (see Figure 2.0-1). Likewise, the proximity of numerous other lower level air traffic facilities adds to this mix. PHL has 26 airports with instrument approach procedures within its jurisdictional boundary including North Philadelphia, Pennsylvania, Willow Grove (Pennsylvania) Naval Air Station, Trenton, New Jersey, and Wilmington, Delaware. The two ARTCC facilities that feed arrival traffic to PHL, ZNY and ZDC, also handle significant amounts of traffic to many of these other terminal facilities and airports.

Accepting air traffic from two different ARTCC facilities into a common terminal facility is not unusually difficult for ATC personnel using current operational procedures and traffic loads. However, current traffic delays and projected traffic growth make the potential gains in airspace efficiency and/or increased airport/runway capacity associated with the introduction of new automation functionality, such as TMA, attractive. The introduction of TMA to the PHL environment is intended to provide the controllers with a tool that assists in the creation of an arrival stream of aircraft that will continue the present high level of safety while effectively and efficiently supplying traffic to PHL. During heavy traffic, TMA will be used to achieve the engineered airport acceptance rate while minimizing aircraft delays. The ability to plan for future flow constraints, instead of reacting to imposed restrictions, will support both ARTCCs and the TRACON in achieving these results. With the support of TMA, inefficient practices currently utilized today, such as frequent use of holding, will be replaced with more efficient operations.

As is always important when considering the development of advanced ATC automation systems, it is necessary to ensure that current operations are easily transitioned to incorporate the advantages of TMA. There cannot be enough attention paid to the significance of controller confidence in the operational impact of TMA. Controller and user acceptance is of paramount importance. This includes both single facility issues (procedural and integration with existing facility automation) and the development of interfacility coordination and integration. The impact of new hardware/software placement must also be considered. The impacts of future enhancements to the NAS also deserve attention, as configuration management of software or hardware at the National level could be affected. In short, every aspect of the three facilities' (ZNY, ZDC, and PHL) current and future ATC operations, including planned changes, must be examined. These areas of concern have all been addressed, at some level, within the operation concepts proposed and within the work plan.

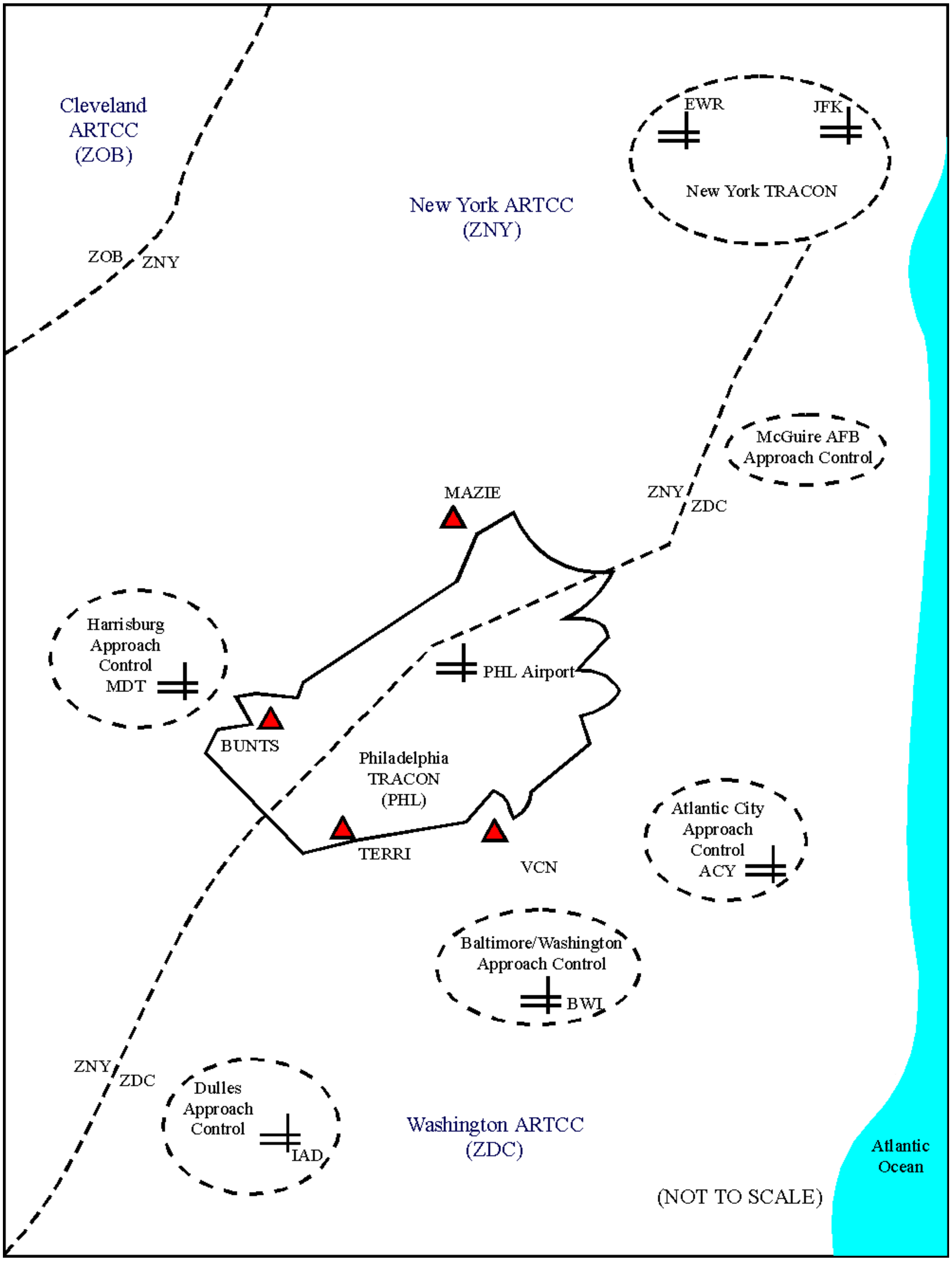


Figure 2.0-1: Overview of PHL and adjacent facilities.

The goal of this study was not to reinvent TMA, but to establish an initial understanding of PHL, specifically in the context of developing modified operational concepts and algorithms for the implementation of TMA. Every attempt was made to identify the most effective modifications to TMA that would allow for rapid implementation of a new system concept, while achieving significant benefits. To define the necessary modifications to TMA requires a description of those characteristics of the operations at PHL that differ from those assumed by the current concept for TMA. This is accomplished within the next section by describing the operational differences between ZFW, the airspace for which TMA's current system concept has been refined, and PHL. The current TMA system concept and functionality are not described in detail in this document. For details on TMA's current functionality, refer to the Traffic Management Advisor TMA Supervisor's Reference Manual (Release 5.3.1acft).

3.0 Comparison of TMA at Dallas/Fort Worth (DFW) and PHL

The development of TMA and its implementation in support of arrivals to DFW has met with a high level of success. The acceptance of TMA by both controllers and users has been phenomenal. This auspicious beginning provides a sound basis upon which to develop the implementation of TMA in support of arrivals to PHL. The airspace and operations surrounding PHL, however, have some significant differences from those surrounding DFW. These differences are the reason why a modified operational concept is required for PHL.

The most obvious difference is that two ARTCC facilities, New York (ZNY) and Washington (ZDC), feed arrival traffic to PHL, as opposed to the single ARTCC, Fort Worth (ZFW), that feeds DFW. The relative locations of ZNY, ZDC, and PHL are illustrated in Figure 2.0 –1. The four metering fixes, BUNTS and MAZIE in ZNY and TERRI and VCN in ZDC, are also shown. Handling the coordination between these two facilities in the effective management of the PHL traffic is a large factor in the development of operational concepts for these facilities. Currently, ZNY and ZDC coordinate independently with PHL and with each other. Neither ARTCC is aware of the other ARTCC's arrival situation regarding PHL. Only PHL has a situational awareness of traffic from both ARTCCs, but this awareness is limited to the traffic crossing the TRACON boundary. It is an objective of the study team that at least one concept explored would attempt to improve this situation.

In Dallas, the DFW airport and its supporting airspace are located virtually in the center of ZFW, with the boundary of other facilities many miles away. This allows the en route facility sufficient time and distance to regulate and manage the flow. Therefore, the airspace surrounding DFW is virtually dedicated to serving DFW with no major ATC terminals or other traffic flows in conflict. All the arriving traffic is, or can be, scheduled in ZFW for DFW. Any interfacility coordination is limited to the two facilities, ZFW and DFW.

In ZNY and ZDC, significant traffic flows associated with other major terminal facilities that are in close proximity to PHL (see Figure 2.0-1) impact the handling of arrivals to

PHL within ZNY and ZDC. For example, traffic from Boston destined for PHL is kept off the coast to avoid Kennedy, Newark, and LaGuardia traffic inland. Dulles arrival traffic west of PHL impacts arrival flows of PHL traffic from the west in the ZNY airspace. BWI arrival and departure traffic impacts ZDC traffic arriving at PHL from the south and east. These other traffic flows are a significant part of operations within these ARTCCs and negative impacts to PHL arrivals can have severe impacts on these other arrival flows.

The distance from the ZNY/PHL boundary at BUNTS, west to the Cleveland ARTCC (ZOB)/ZNY boundary is short enough that ZOB is impacted if more than a few aircraft are held over BUNTS (see Figure 2.0-1). This distance of 106 n.mi. (typical transit times of 15-20 minutes) is even shorter than ZFW's minimum distance from ARTCC to TRACON boundary of 124 n.mi. (typical transit time of 18-22 minutes). When ZNY is impacted by holding for PHL, this impact often ripples back into ZOB. Coordination between ZNY and ZOB will be required whenever ZNY needs to impose restrictions.

In any ATC facility, the holding of aircraft outside the TRACON is inevitable for reasons too numerous to mention. Some planned holding has long been advocated by the air carrier community as a way to make certain there are no "gaps" on the final approach course. They feel this is a good way to "keep the hopper full" and make sure controllers always have an arrival aircraft in position to fill any gaps on final. This theory has resulted in several facilities, including PHL, being designated at one time or another as managed arrival reservoir system (MARS) facility. This designation permits a flow control program, such as arrival delay, to schedule a few additional aircraft over and above the engineered airport acceptance rate when delays are in effect to ensure enough aircraft to achieve dynamic changes in achievable acceptance rates. Currently, PHL uses holding as a normal procedure for achieving desired acceptance rates under normal traffic flows (as opposed to off-nominal situations like extreme weather). Holding occurs at PHL several times a day and most days of the week. Holding is not used in a similar manner at ZFW.

Unlike DFW, the delegated airspace making up the PHL TRACON is not easily described. PHL is located almost directly under the boundaries of ZNY and ZDC, where DFW is totally contained within the confines of ZFW. PHL TRACON does not lend itself to any symmetrical distribution or depiction of where air traffic enters TRACON airspace. This complexity does not impact normal flows of traffic within the ARTCCs because they follow regular paths that end in a metering fix at the TRACON boundary, so their boundary crossing location is easily defined. For aircraft that are routed other than over one of the four metering fixes, the location of the TRACON boundary will be difficult to represent with a simple airspace geometry, so the boundary crossing location for these aircraft will be difficult to define within TMA.

DFW is a rather large airport, with several arrival runways activated at one time. This allows changes in runways (and runway balancing) to largely affect the arrival rate of the airport and the flexibility of the Traffic Management Coordinator (TMC) to modify an initial TMA schedule. In PHL, only a single runway (27R or 9R) is used for the main jet arrivals, a short runway (17/35) is used for propeller arrival traffic, and a single runway (27L or 9L) is used for departures. This severely reduces the flexibility of the TMC in improving the arrival rate. While DFW also has “reliever” runways, the comparisons are uneven in number and availability. DFW makes use of several of their longer runways for such purposes. PHL currently only has the one short runway. Another short East/West runway is under construction, but is not anticipated to provide significant relief because of its proximity to the main passenger terminals. Its use will be severely restricted to departing only to the East and arriving to the West for props and lighter jet aircraft.

Over the years, the development of traffic management automation has increased the role of traffic managers within ZFW and DFW. This evolution has not yet occurred to the same degree in the Eastern Region (especially not in PHL). The TMUs (and controllers) in these facilities are not currently used in a manner assumed by the current TMA concept. None of these facilities have any metering experience with the Arrival Sequencing Program (ASP). PHL TMCs are not currently staffing the TMU on a full time basis because the facility has determined they are needed to respond as necessary during heavy traffic pushes and are not needed during lighter flows. Even the physical layout of the PHL TMU may need adjusting to accommodate the use of TMA displays. The introduction of TMA will likely make significant changes to these environments to enable the necessary monitoring of TMA to take full advantage of its usefulness as a planning tool. Even though the ATC culture, not the TMA concept, may have to change to accommodate TMA, this is a significant difference between ZFW/DFW and ZNY/ZDC/PHL.

ZNY and ZDC sector sizes are generally smaller and more complex than ZFW sectors. This reduces the amount of delay a controller can absorb within their airspace and will add to the challenge of training controllers to accurately meet TMA generated schedule times of arrival (STAs). It is reasonable to anticipate the need to possibly establish secondary/preliminary feeders fixes and associated STAs in sectors not feeding arrival traffic directly to PHL (e.g., outer metering fixes). Further consideration must be made to the possibility of reaching out to adjacent centers, such as ZOB, to maintain consistent traffic flows capable of meeting TMA generated STAs. This level of detailed planning will have to be negotiated at the facility level as TMA is introduced to PHL.

In PHL TRACON, Tower En Route traffic makes up a large part of the arrival traffic. Most of this traffic is sent to the smaller 17/35 runway and does not directly impact arrivals landing on the main jet runway. Since DFW does not have a significant amount of Tower En Route traffic, the handling of Tower En Route, either directly or indirectly, will need to be added to the TMA concept for PHL.

Because of the large number of ATC facilities located in the relatively small area of the Northeast United States, the Air Traffic System Command Center (ATSCC) in Herndon, Virginia takes a very active role in the management of traffic in this area. For the majority of decisions involving interfacility coordination (including the addition of miles-in-trail restrictions), ATSCC is involved. Today, the request for miles-in-trail restrictions to avoid holding procedures often ends with ATSCC turning down the request for operational reasons not obvious to the requesting facility. The integration of TMA must address this interaction. This may involve nothing more than a policy decision by FAA air traffic management in Washington Headquarters and facility management at Herndon to abide by TMA determination of the need for restrictions. Consideration should be given to the advantages and disadvantages of providing a TMA display at the Herndon facility. In any case, the potential involvement of the ATSCC must be considered in any transition of PHL to a TMA operation.

All of the above factors have a pronounced impact on the modifications required to the TMA concept for implementation for PHL.

4.0 Benefits of Applying TMA to PHL

Through discussions with controllers and operations specialists at PHL, ZNY, and ZDC, many potential benefits for the implementation of TMA were identified. These benefits include gains in capacity, as well as general improvements in facility coordination and controller workload. As with any system development in the concept phase, these benefits still need to be validated quantitatively. Qualitatively, initial indications are that the major identified benefits are achievable.

The current, nominal method of regulating traffic at PHL is to impose holding procedures. Unlike other facilities, holding procedures at PHL are not just reserved for large delay situations typically caused by weather or other extreme operational conditions. Holding at PHL is a regular operational procedure, typically occurring several times a day and most days of the week. The reason PHL uses this procedure during nominal operational conditions (not just extreme operations) is their lack of ability to accurately predict and plan accordingly for when their daily rushes occur.

In today's operations, ZNY and ZDC continue to feed traffic to PHL at an unrestricted rate until the arrival controller in the TRACON becomes saturated. At that time, the arrival controller informs the ARTCCs that PHL can no longer accept additional traffic and that holding must be implemented. This usually occurs without warning and therefore without planning. Anecdotal evidence from ZNY indicates that controllers in the ARTCCs actually attempt to anticipate when PHL will "close the door" by observing the increasing length of time it takes the arrival controller to accept succeeding handoffs. At best, this method is limited in its ability to allow sufficient planning horizons for effective operations in the ARTCCs. When ZNY tries to implement MIT restrictions to decrease the arrival rate before holding, this is often met with resistance from the ATSCC due to a concern of "over regulating" the flow and decreasing the arrival rate. This reluctance to initiate MIT restrictions by the ATSCC is driven by user concerns about the implications of any "built-in" delays in the ATC system. The users monitor such restrictions with a great deal of scrutiny.

Holding operations, especially those that are not predicted and planned for, have several negative impacts on the operations in the ARTCCs and in the throughput at PHL. In the

TRACON, an arrival controller will not begin to take aircraft out of the holding pattern until the current traffic situation that caused the overload has been pretty much cleaned up. As a result, gaps in the arrival stream can occur and the arrival rate is negatively impacted. Once the controller does begin to take aircraft out of the holding pattern, it is very likely that the aircraft are not in an ideal position to enter the TRACON airspace without some delay (i.e., the aircraft is not heading towards the airport and must make a time consuming turn). This can also have a negative impact on the arrival delay. Also, the holding patterns for PHL, especially in ZNY, take airspace away from the airspace that handles the PHL departure streams. Because of this, the departure rate from PHL can be negatively impacted as well. From an airline's perspective, holding aircraft, especially at lower altitudes, consumes excess fuel.

In the ARTCCs, holding generates a ripple effect down the line of aircraft, causing congestion and increased tension. This increases controller workload, especially if the amount of traffic being affected is large. This impact will grow as the traffic grows, as current predictions of future operations indicate for PHL. Since ZNY and ZDC have large amounts of arrival traffic going to major terminals other than PHL, this ripple effect can impact them as well, including causing the increase of delays to these other facilities.

The insertion of TMA into this environment will have many positive impacts. Under nominal, predictable conditions, TMA has the ability to predict when the volume of traffic into PHL will exceed the acceptable arrival rates well in advance of the traffic saturating the arrival controllers. TMCs would be able to monitor the inbound flow for up to ninety minutes in advance and detect "bunching up" of traffic. This would allow the TMCs to take the necessary action to spread out the traffic. Through the use of metering, or even as a tool for identifying when MIT restrictions should be implemented, TMA can support the application of minimum restrictions to reduce the traffic flow to an acceptable level. By planning and implementing these programs early enough, the flow rate can be reduced to a level that does not saturate the arrival controllers and create the need to "close the door," and therefore all of its related negative impacts can be avoided. With early implementation, ARTCC controllers can develop plans to avoid the problems caused by the ripple effect in the ARTCCs. In general, holding and all of its negative impacts will be minimized.

Through the ability to predict the impact of traffic flows well in advance of potential PHL saturation, early coordination can be effected with the facilities involved to resolve potential problems. In today's operation, ZDC is not aware of the arrival traffic situation between ZNY and PHL. The reverse is also true. In fact, it is difficult to get one ARTCC to even consider such "superfluous" information. Their respective attitudes reflect an interest in moving their own traffic efficiently out of their airspace and into the terminal area. The only time they are aware of each other's PHL arrival traffic is when PHL halts inbound traffic by "shutting the door" and commences holding in ARTCC airspace because of traffic volume aggregated from both ARTCCs. The introduction of TMA and the associated displays will do much to correct the current absence of this common data.

This improved coordination not only includes the three facilities directly impacted, but facilities adjacent to these as well. For example, due to the limitations in the distance between the ZOB/ZNY border and the ZNY/PHL border, it is anticipated that coordination between ZNY and ZOB will occur regularly during restricted flow operations. TMA will support ZNY in making better decisions on how ZOB should restrict their flows into ZNY. The introduction of TMA will greatly enhance their ability to deal with heavy rushes of arrivals during peak traffic periods as well as handle the anticipated traffic increases of the future.

In highly unpredictable situations (e.g., extreme weather situations and sudden runway closures), the worst case is that TMA is not helpful and operations occur as they do today. Since holding is a normal, not an off nominal condition for PHL, it is expected that the benefits of implementing TMA would be achieved on a regular basis with a large quantitative benefit.

The removal of the negative impacts of holding is an immediate benefit expected by implementing TMA at PHL. The team is also confident that once TMA is inserted into the operation, the system will be utilized more effectively (and more benefits will be achieved) as the facilities become more comfortable with the functionality. For example, PHL has recently begun (within the last four months) to utilize runway 27L for arrivals (predominantly the departure runway) to offload the continual pressure on runway 27R (the main arrival runway for jets). This is currently done when the opportunity to change runways is identified while the aircraft are within the TRACON airspace. This does not affect the airport’s throughput, but does increase the controller’s flexibility in landing the aircraft already present in the pattern. With the use of TMA, it is fully anticipated that the scheduling of this other runway could be done strategically, while the aircraft are still within the ARTCC airspace. This strategic planning would allow the relief of the load on 27R while increasing the airport’s effective throughput.

5.0 Complications Due to the Two ARTCC Environment

As described earlier, the original concept for TMA was built around supporting metering at a single TMU, within a single ARTCC, transitioning aircraft to a single TRACON. Since the TMA had information on all traffic transitioning to the TRACON and the TMU that it supported had the authority to modify trajectories (e.g., delay) for any of these aircraft, the TMA functionality was designed to use maximum flexibility in distributing delay in an effective and equitable manner. Unfortunately, the lack of a single ARTCC TMU with ultimate control and authority over all aircraft arriving at PHL causes complications in the adaptation of the existing TMA algorithms to the operations in this airspace.

One method for dealing with these algorithmic and operational complications is to functionally ignore the distinction between the two facilities and create within TMA the idea of a “super” ARTCC. By having access to all of the traffic and airspace information for both ARTCCs, TMA functionality can effectively ignore the ARTCC boundaries and handle the scheduling of traffic as if there were just a single ARTCC. This allows TMA to retain all of the functionality and flexibility of the existing concept for a single ARTCC and TRACON. The problem with this method is that the amount of coordination required between the two ARTCC facilities could get extremely large. Since TMA would consider the two ARTCCs as part of the same super ARTCC, displays in both ARTCC TMUs would have access to the same data. Theoretically, any input that one ARTCC TMC enters could affect what the TMU in the other ARTCC is trying to accomplish. For example, manually changing a schedule in one ARTCC to alleviate a local problem could ripple the schedules in the other ARTCC due to new interactions between aircraft from the two facilities at the runways. It is expected that operational procedures would have to be developed to ensure that one facility didn’t negatively affect the other. Possibly, software modifications limiting the impact of one facility on the other would be required. If so, these limitations would impact the ultimate benefits achievable by TMA by limiting its algorithmic flexibility. Even if limitations are necessary, though, the benefits achievable by a limited system are still expected to be significant.

A second method for dealing with the algorithmic and operational complications is to develop operational limitations for the system outside of TMA, and then let TMA retain its complete flexibility within these outer limitations. In essence, the limitations replace the additional coordination required in the “super” ARTCC case. The method identified and proposed within this study is to develop separate arrival (acceptance) rates for the two ARTCCs based on the overall arrival rate for PHL.

The overall arrival rate for PHL would be derived from historical data from the Enhanced Traffic Management System (ETMS) and the daily planned operations given the airport configuration (as is done today). This rate would then be divided between the two facilities with the larger allocation going to the busier facility. An example of this would be, at the start of the day most of the arrivals destined for PHL arrive through ZNY airspace. If the overall arrival rate at PHL were 60 aircraft per hour, a potential allocation would be 40 aircraft per hour for ZNY and 20 aircraft per hour for ZDC. If the arrivals were heavier from ZDC, the allocation would be 40 aircraft per hour for ZDC and 20 aircraft per hour for ZNY. The sum of the arrival rates could, in some instances, be more than the engineered arrival rate. The actual desired numbers would be developed through experience with the three facilities. This process is similar to how Denver Center handles the application of mile-in-trail restrictions on the East and West sides of the ARTCC, based on the airport configuration and time of day. Once the values are determined, the two facilities can act independently of each other, as long as they do not violate their individual arrival rates for PHL.

The implementation of the divided arrival rates can be handled in a variety of ways. At the most basic level, this arrival rate could be implemented as miles-in-trail restrictions for each of the ARTCC facilities. This is how operations happen today in many facilities, but as described earlier, the ATSCC often does not allow the application of these MIT restrictions for fear of lost efficiency in over-regulating the traffic flow. If metering were desired, then TMA could be implemented in one ARTCC while the other implemented MIT (or free flowed if this was determined to be acceptable) or both ARTCCs could implement independent TMA systems to meter to their individual arrival rates.

Metering, in general, allows the automation system the greatest flexibility in distributing delays dynamically among aircraft to achieve the most efficient arrival rates into the TRACON. If the entire arrival traffic is available, then the arrival rate of any metering fix can be dynamically adjusted to account for a decrease (or increase) in load over another fix. If all metering fixes are adapted in TMA, then balancing of traffic load can occur between any two (or more) fixes. By metering over a subset of metering fixes (i.e., just the fixes within a single ARTCC), the ability to dynamically redistribute arrival rates over those fixes is still achievable, even if the redistribution can not occur between all metering fixes (i.e., between the two facilities). Since the dynamic readjustments between fixes is achievable within an ARTCC, benefits greater than those through the use of fixed MIT restrictions at all fixes is achievable. Therefore, the use of MIT restrictions at each fix would, in itself, be a benefit. The use of metering in one facility and MIT restrictions in the other would achieve a greater arrival rate benefit. The use of metering independently in both facilities would achieve an even greater benefit. The use of metering at all fixes in a dependent way would achieve the ultimate arrival rate benefit.

There are potential ways in which procedurally some of the limitations in dividing the arrival rate could be reduced. For example, if the facilities use TMA to predict that a lull will occur over one of the previously loaded metering fixes, the three facilities could agree to reallocate the arrival rates at a future time. The current functionality to propose future arrival rate (or configuration) changes within TMA would support this operation.

These two methods are a basis for discriminating between the operational concepts described below. The use of a single TMA system that handles the two ARTCCs like a single “super” ARTCC is the basis for the TRACON Concept and the Single and Dual-

Center Dependent Concepts. The use of a divided arrival rate between the two ARTCCs is the basis for the Single and Dual-Center Independent Concepts.

6.0 Potential Operational Concepts

Based primarily on the requirement for effective coordination between the TRACON and the two ARTCC TMUs to regulate the flow of aircraft into the TRACON, five potential operational concepts have been identified. These five concepts are each described below at a high level, with emphasis placed on the concept benefits and difficulties. Section 7.0 presents a detailed description (including a representative scenario) of the concepts (one based in the TRACON and one based in the ARTCCs) determined to have the best combination of positive impact and minimal risk. For the detailed descriptions, the implications of workload, staffing, coordination, procedures, equipment placement, automation integration and adaptation were also considered.

The distinguishing feature of each of the five concepts is a combination of which TMU is given the responsibility for developing the traffic management restrictions and the amount of coordination required between the two ARTCCs. In the first concept (referred to as the TRACON Concept), PHL TRACON is given the responsibility for developing the required flow restrictions (in this case, miles-in-trail restrictions) and there is little coordination required between the two ARTCCs. In the two Single Center Concepts, only one ARTCC (either ZNY or ZDC) has the responsibility for developing the required flow restrictions (in this case, metering times). For the Single Center - Independent case, that ARTCC has minimal required coordination with the other ARTCC while in the Single Center - Dependent case, significant coordination is required between the two. In the two Dual-Center concepts, each ARTCC develops the required flow restrictions (again, metering times) in their own airspace. In the Dual-Center - Independent case, the two ARTCCs work autonomously (i.e., with minimal coordination) while in the Dual-Center - Dependent case, the two facilities must significantly coordinate with each other.

In all concepts, significant coordination is required between each ARTCC and the TRACON. By the use of displays in all three facilities, TMA data would be shared by all facilities. This is an aspect of TMA that will greatly improve the current PHL/ZDC/ZNY coordination and traffic management process. Under the current ATC system, PHL communicates and coordinates arrival traffic information independently with each of the two centers. Most of this coordination is done controller to controller via telephone landline and ARTS IIIA computer input/output. With the installation of TMA displays at all three facilities, the three facilities will be able to simultaneously observe the total inbound traffic picture and make appropriate decisions.

Also, all concepts require that all restrictions be coordinated with and implemented by the ARTCC in which they are being implemented (i.e., ZNY implements ZNY flow restrictions and ZDC implements ZDC flow restrictions). Differences in which facility “develops” the required flow restrictions represent different ways in which information can be viewed and manipulated within TMA. This will be made clearer in the concept descriptions below.

6.1 TRACON Concept

As the name implies, the TRACON Concept focuses on putting TMA functionality (and associated hardware/software) within PHL TRACON. This TMA concept focuses on the TRACON Traffic Management Coordinator (TMC) in PHL as the individual who identifies and develops solutions within TMA and coordinates the resultant traffic management flow restrictions for the four metering fixes with the appropriate ARTCC TMU. Since the TRACON TMU has no authority to implement restrictions within the adjoining ARTCC, the TRACON TMC has the responsibility to coordinate with the ARTCC TMUs to implement appropriate restrictions that achieve the desired arrival rate into the TRACON. It is highly desirable, though not actually required, to have slave displays of TMA information within each of the ARTCC TMUs to facilitate coordination and the identification of potential improvements to the traffic flow.

In this concept, the TRACON TMC monitors the TMA timelines and load graphs for the four metering fixes, looking to identify time periods where the traffic volume is predicted to exceed the accepted TRACON arrival rate(s). When the TRACON TMC identifies a time period where the arrival rate will be exceeded, the scheduling capability of TMA will be used to develop a Restrictions Program for implementation. Since it is not realistic for a TRACON TMU to implement a metering program within an adjacent ARTCC, the required traffic management restrictions will be implemented as miles-in-trail (MIT) restrictions. These MIT restrictions can be easily coordinated with the adjoining ARTCC through standard landline communications. How the MIT restrictions could be generated is described in Section 7.1.

Though the use of MIT restrictions does not present the same potential for maximum benefits as the use of metering (see Section 5.0), the effective application of MIT restrictions still presents an opportunity to gain significant benefits. In current ATC operations, flow control, holding, traffic volume, weather, staffing, equipment outages, and other variables routinely dictate MIT spacing of aircraft and other traffic management decisions. TMCs have few tools that permit accurate, timely, objective decision making for the determination of applying MIT restrictions. With the use of automation such as TMA, an efficient schedule for the magnitude and duration of MIT restrictions can be determined to provide the minimum impact required to meet the necessary flow restriction.

The strength of this concept is on the fact that a single TMU (in the TRACON) has data for all traffic arriving at PHL and can make impartial decisions that impact both ARTCCs simultaneously. The TRACON TMC will be focusing on the best solution for PHL, and will coordinate with each ARTCC to ensure that their operational requirements are met while making tradeoffs between the ARTCCs without bias. The TRACON TMC will be continuously aware of the conditions at Philadelphia airport as it relates to runway availability, departure demands, Tower En Route activities, equipment status, staffing and any other issue that would affect traffic flows. This allows the TTMC to coordinate with the ARTCC TMUs in a timely manner and to offer dynamic alternatives to improve and smooth out the traffic flow. Just as significantly, the need to divide acceptance rates (and therefor add inefficient buffers) is not required for this concept. Another strength is in the use of MIT restrictions instead of metering. This relieves the need to train ZNY and ZDC in the use of a metering system (neither of these ARTCCs currently meter traffic).

While the removal of training for metering is a concept strength, the use of MIT restrictions will also limit the potential benefits of TMA over metering (see Section 5.0). Even if the MIT restrictions are changed dynamically to meet changing traffic requirements, this is a concept weakness. Another concept weakness is that the TRACON TMC will require significant coordination with the ARTCC TMUs to ensure a solution that does not overly impact ARTCC operations. This is a major change from today's operations, in which PHL plays a much more passive role in this process.

6.2 Single Center – Independent Concept

In this concept, TMA functionality (and associated hardware/software) is implemented within one of the two ARTCCs. The concept is identical whether TMA is implemented within either ZNY or ZDC, but it is expected that greater benefit would be achieved by implementation within ZNY since this facility currently feeds the heavier volume of arrival traffic to PHL. For the remainder of this discussion, it is assumed that TMA will be implemented within ZNY.

The Single Center – Independent concept requires TMA to be adapted for only the ARTCC in which TMA is implemented (e.g., ZNY). The concept assumes that the operations of the adapted ARTCC can be performed autonomously from the operations within the other ARTCC (hence the term "Independent" in the name). Therefore, adaptation of the other ARTCC information within TMA is not required. The ramification of this is that only the traffic and the metering fixes within the adapted ARTCC are available for scheduling. To achieve the independent nature of this concept requires agreements between the respective facilities to establish differing engineered arrival rates for the two ARTCCs based on historical arrival data.

The concept focuses on the ZNY TMC as the individual who identifies and develops solutions within TMA and coordinates the resultant traffic management flow restrictions. Since the TMA is adapted for only ZNY, this concept requires agreements between the respective facilities to establish differing engineered arrival rates for the two ARTCCs based on historical arrival data (see Section 5.0) for the current configuration of the airport. ZNY would use TMA to develop flow restrictions for traffic within its airspace to meet its part of the overall acceptance rate. Since the resultant restrictions (in the form of metering times and lists at the sector controller displays) only impact the metering fixes within ZNY, no coordination is necessary between ZNY and ZDC. Unless a reason is determined for coordination with ZDC, a slave display is not required at ZDC. A slave display in PHL TRACON (similar to that used in DFW TRACON) would help coordination between ZNY and PHL TRACON.

Since TMA is implemented within a single ARTCC TMU, the ZNY TMU would use timelines, load graphs and the other TMA functionality to meter its traffic in a manner consistent with the current operational concept for TMA. ZNY has complete authority over implementing restrictions within its own airspace, so the use of negotiated MIT restrictions (as in the TRACON Concept) is not necessary. The biggest difference between this use of TMA and the current use of TMA at ZFW is that ZNY utilizes TMA to meet only its part of the overall acceptance rate and that the rest of the acceptance rate would have to be managed separately by ZDC and PHL TRACON. This could be done either by free flowing ZDC traffic (if applicable) or by PHL imposing MIT restrictions on ZDC for their portion of the overall arrival rate.

The biggest strength of this concept is the ability to gain the benefits of metering and remove the negatives of holding within one of the facilities. This benefit is gained with a lack of major modifications to either the TMA software or its connections with the FAA's Host system. As discussed in Section 5.0, the ability for ZNY to use TMA would ensure that its traffic is restricted only as necessary, even if ZDC were still handled as today. It is expected that the use of TMA in ZNY could at least achieve the anticipated benefits (including removal of the need for holding over BUNTS and MAZIE) in ZNY. More work would have to be done to ensure that the lack of TMA support for ZDC does not impact the benefits of using TMA in ZNY.

A major weakness of this concept is that PHL will have to split the arrival rate between ZDC and ZNY. This reduces the flexibility of TMA to dynamically change the arrival rates over all metering fixes (in either ARTCC) based on actual traffic demand. Also, PHL will have to develop "rules of thumb" for working with a single ARTCC acceptance rate when determining how aircraft from the two ARTCCs will merge on the runways (e.g., increasing threshold arrival rates to leave slots for ZDC traffic). This will inevitably lead to inefficiencies over using data from both ARTCCs. Another major weakness of this concept is that only part of the arrival traffic receives the benefit of TMA scheduling. Though ZNY does have the majority of traffic to PHL, the traffic from ZDC is not insignificant and the lack of an ability to effectively manage this traffic is expected to be significant.

6.3 Single Center – Dependent Concept

This concept is similar to the Single Center – Independent concept, with two significant exceptions:

1. TMA would have to be adapted for both ARTCCs.

2. One ARTCC TMU (e.g., ZNY) would develop the required flow restrictions and coordinate with the other ARTCC TMU (e.g., ZDC) to implement restrictions for metering fixes not in its (ZNY's) airspace.

The most effective way of doing this would be a combination of the two concepts described in Sections 6.1 and 6.2. For restrictions internal to ZNY, metering could be used as in the Single Center – Independent concept. For implementation of flow restrictions within ZDC, miles-in-trail restrictions could be used in a similar fashion as described in the TRACON Concept.

Though many of the weaknesses in the Single Center – Independent concept are avoided in this concept, they come at the price of increased coordination and the potentially sensitive situation of having one facility with at least a perceived authority over the other (since only one will have access to inputs to TMA).

6.4 Dual-Center – Independent Concept

In essence, the Dual-Center – Independent Concept is just two Single Center – Independent concepts running simultaneously. Separate TMA functionality (and associated hardware/software) is implemented in each of the ARTCCs, but there is no connection between the two systems. Each TMA is adapted for just the facility within which it is being used and a slave display is provided for the other ARTCC and PHL TRACON. These slave displays would be provided only to allow the other facilities to observe the traffic from the other fixes and provide a more informed level of coordination, where necessary.

As in the Single Center cases, PHL would have to develop acceptance rates for the two facilities based upon the current configuration. Once each facility has its own arrival rates, then the two TMA can function independently, building schedules for only their part of the overall arrival rate. In other words, the TMA in ZNY would develop metering lists for BUNTS and MAZIE based on ZNY's arrival rate and the TMA in ZDC would develop metering lists for Cedar Lakes and TERRI based on ZDC's arrival rate. Since both ARTCC TMUs have TMA running (with slave displays of TMA information from the other ARTCC), dynamic changes can be coordinated between the two facilities (and PHL) as desired, based upon actual traffic conditions. Once all external coordination is completed, each ARTCC TMU runs its own metering independently.

This concept has the strengths of the Single Center – Independent Concept, with the additional benefit of handling all of the traffic from both ARTCCs. If traffic is such that just ZNY or ZDC needs to be metered, the other facility does not even have to get involved. There is also the added benefit of coordination between the facilities, as desired. This coordination is not required, so the negative impacts of the Single center – Dependent concept are avoided.

The major weakness of this concept is the lack of integration between data from the two ARTCCs. The major impact this causes is the inability to automatically change (within TMA) the acceptance rates between the two ARTCCs, as traffic dynamically dictates. For the same reason, it is not possible to display data from the two facilities on the same timelines or load graphs (e.g., on a threshold timeline). To handle these deficiencies, the acceptance rates for the two ARTCCs will have to be padded somewhat to reduce the chance of overloading the TRACON. Even if this overloading occurs, the worst case is to go into a short holding period (which is what happens today) to decrease the excess traffic load.

6.5 Dual-Center – Dependent Concept

In this concept, a single TMA system is adapted for both ARTCCs and full displays (not slaves) are installed in both ARTCC TMUs. A slave display is installed in the TRACON TMU to facilitate coordination. The idea is to functionally ignore the ARTCC boundaries, but to deal with the operational implications through coordination between the two ARTCC TMUs.

This concept focuses on both ARTCC TMCs as key members in the identification and development of traffic management flow restrictions for the two ARTCCs. When a metering situation is identified by either of the ARTCC TMUs, the two TMUs must coordinate an acceptable solution that takes the needs of both TMUs into account. Once a mutually agreeable solution is identified, each TMU takes responsibility for the implementation of their part of the solution (i.e., each TMU performs metering on just their facility's metering fixes). As far as the single TMA system knows, there exists only a single "super" ARTCC.

The strength of this concept is that it allows the ultimate flexibility in the scheduling of traffic. Since TMA has data for all arrival traffic, it can effectively meet dynamic changes in the traffic load by balancing traffic among all metering fixes (independent of facility). The system can dynamically adapt to traffic load decreases in one facility by increasing the acceptance rate in the other, enabling the maximum potential to achieve the benefits associated with metering. Also, all facilities will have complete and integrated displays of data, allowing the elimination of extraneous "buffers" that are caused by incomplete data and the ability to make the best informed decisions.

This increase in flexibility does come at a rather high price. The coordination required between the two facilities increases dramatically. Because there is only a single system, any changes made by one ARTCC TMU can directly impact the other in unexpected ways. For example, a manual change by ZNY may change the interaction of aircraft on the threshold and thereby, cause a ripple in the ZDC list. This highly coupled nature will cause a large amount of coordination and potentially unacceptably large increases in workload.

7.0 Detailed Concepts – TRACON and Dual-Center Independent

In Section 6.0, five viable operational concepts were presented for the application of TMA functionality to improve the handling of arrivals into PHL. Though each of these concepts could be developed into a successful prototype system and ultimately result in operational benefits for PHL and the surrounding ARTCCs, they vary in level of potential benefits, impact on current operations, and user/political acceptability level.

The five concepts were evaluated and the two determined to have the most desirable tradeoff between potential benefits and risks are described below.

The first concept chosen for detailed description is the TRACON Concept. Even though this concept (as currently conceived) does not allow for metering, the low risk of using established miles-in-trail restrictions and implementation within only a single facility makes for a higher benefits-to-risk ratio. It was also known that several outside organizations were suggesting TRACON concepts for the implementation of TMA at PHL as an initial step, and the team wanted to make sure that this concept was fully explored as part of this study.

The second concept chosen for detailed description is the Dual-Center – Independent Concept. This concept was determined to be the best ARTCC-centric concept of the ones explored in terms of total benefits-to-risk ratio. This concept has the same basic risk as the Single Center – Independent concept, but significantly more potential benefit (without the increased risk of the Dependent concepts). It is also a potential initial phase for development to the highest potential benefit (but riskiest) Dual-Center – Dependent Concept.

The two concepts presented are the ones felt by the authors of this study, based upon their existing knowledge, to be the "best" concepts for initial exploration. As mentioned above, all of the concepts are expected to be beneficial and the decision of a concept different from the two described may be desirable based upon other factors (e.g., political) unknown to this team. It is felt that the details described below for these two concepts will help in the development of any proposed concept.

7.1 TRACON Concept

The TRACON concept, described at a high level in Section 6.1, represents an excellent strategy for a limited implementation of TMA for PHL. This concept minimizes the combined operational impact of TMA implementation on the three facilities (ZNY, ZDC, and PHL) by focusing mainly on changing PHL operations, but at the cost of limiting maximum achievable benefits. The development and implementation of this concept will most likely result in the quickest implementation of TMA for PHL, but the system would not be easily expandable to achieve the benefits of an ARTCC-based system.

As described in 6.1, this concept focuses on putting the TMA system within the TRACON TMU, with slave displays of information at the two ARTCC TMUs. The concept relies upon TMA having track and flightplan information for both ARTCCs within a single TMA so the TRACON TMC can get an accurate arrival picture for the entire TRACON. For the impact of this requirement on TMA adaptation requirements, see Section 9.1.

The main "user" of TMA in this concept is the TRACON Traffic Management Coordinator (TTMC). The TTMC will be responsible for developing and setting up the key parameters within TMA (e.g., current and proposed configurations and runway, airport, and terminal acceptance rates) and for monitoring the system to identify when the predicted traffic load is expected to exceed acceptable levels. With access to both ZNY and ZDC data within TMA, the TTMC will be able to simultaneously monitor the traffic load over each of the four metering fixes (potentially up to 90 minutes in advance of crossing the TRACON boundary) and to assess the impact of merging ZNY and ZDC traffic on the runway thresholds. As traffic predictions begin to exceed the acceptable arrival rates entered into TMA (as shown by data on load graph and timeline displays), the TTMC will evaluate TMA scheduling and utilize TMA functionality (in a manner similar to ZFW operations) to develop a plan for the arriving traffic. Since TMA contains information (track and flightplans) for all aircraft requiring scheduling into PHL, a plan can be developed that achieves all flow constraints and distributes delay in an efficient and equitable manner (between metering fixes in all facilities). Though the data available to the TTMC is equivalent to the data available to an ARTCC traffic management coordinator (e.g., in ZFW), the perspective of the TTMC is significantly different from the ARTCC equivalent. For a detailed description of the impact of this concept on the use of TMA functionality, see Section 8.0.

Because the TRACON TMU does not have the authority to implement restrictions within an adjoining ARTCC facility, the use of TMA to create metering times for display at ARTCC sectors is operationally unacceptable. This would also be functionally cumbersome since the TTMC would have to significantly coordinate with the ARTCC TMUs to support metering operations within the ARTCC facilities. To alleviate these problems while attaining a significant portion of the benefits provided by TMA, this concept proposes a functionality called “equivalent miles-in-trail” restrictions.

Equivalent miles-in-trail restrictions are dynamic MIT restrictions that are negotiated between the TTMC and the ARTCC TMUs for implementation within the ARTCC facilities. Based upon a developed time-based schedule, TMA would convert this schedule into segments of MIT restrictions for each metering fix that would approximately create the same traffic flow into the TRACON as represented by the original schedule (see example scenario below, Section 7.3.1). These equivalent MIT segments could either be added after the schedule is complete (i.e., as an approximation of the schedule) or the scheduler could be developed to generate the MIT restrictions and then reschedule the aircraft based on the MIT constraints (i.e., STAs would meet MIT constraints). A manual ability to input desired MIT restrictions (e.g., to allow a TMC to refine the equivalent MIT values) and to see the effect on the STAs would be beneficial.

By breaking the traffic into segments, the equivalent miles-in-trail restrictions could be “turned on or off” or modified as necessary to impose the least amount of restrictions required to meet the arrival rate requirements (i.e., only those metering fixes requiring restrictions would have them imposed). By using TMA and the time-based schedule as the reference, a plan can be developed for the application of these restrictions and negotiated in advance with the ARTCC TMUs. If the scheduler is adapted to generate STAs that meet the equivalent MIT values, then the delays imposed by adding the constraints can also be evaluated and refinements made through modifications to the MIT values. By agreeing on the minimum number of aircraft (or minimum time) for a

MIT segment, the ARTCCs and TRACON can minimize the number of dynamic changes to the MIT restrictions at each fix.

There is actually a tradeoff between the dynamic nature of the restrictions (how many different MIT segments are allowed) and the amount of benefits that can be achieved. In this vein, time-based metering can be thought of as an equivalent MIT situation where the minimum number of aircraft within a segment is two. This would allow for the most flexibility in assigning constraints and therefore, the most benefits. Of course, this also has the largest associated workload. Static MIT restrictions, as are typically implemented today, would be the equivalent of setting the minimum number of aircraft in a MIT segment to equal the total number of aircraft (in a single streamclass) within the rush period (i.e., a single segment per metering fix for the duration of the rush period). This would have the least amount of associated workload (i.e., least amount of required coordination), but the least amount of flexibility and benefits as well.

To finalize a plan for both facilities, the TTMC will coordinate with each of the ARTCC TMUs to achieve agreement on the final restrictions. The use of slave displays within each of the ARTCC TMUs will be invaluable towards facilitating this coordination. Once agreed upon, it is then the responsibility of the ARTCC TMUs to implement the MIT restrictions at the appropriate metering fixes and at the appropriate time(s). Because TMA will allow for the early planning of these imposed acceptance rate reductions, the ARTCC TMUs will have more time to plan how they will accommodate the MIT restrictions and the resulting impact on non-PHL arrival flows in their airspace. The ARTCC TMUs will also be responsible for coordinating appropriate restrictions with other ARTCC facilities that they feel are necessary to support the implementation of the plan (e.g., ZNY coordinating with ZOB for arrivals over BUNTS). Since the ARTCC TMUs have to deal with significant flows to other terminal areas, often at the same time as when the flow into PHL is at a peak, this concept can achieve some relief for them during busy periods while achieving acceptable flow rates into PHL.

7.2 Dual-Center Independent Concept

The Dual-Center - Independent concept, described at a high level in Section 6.4, represents an excellent strategy for a limited implementation of TMA as an ARTCC-based tool for PHL. This concept minimizes the combined operational impact of TMA implementation on the three facilities (ZNY, ZDC, and PHL) by focusing on implementing TMA within the two ARTCCs in such a way that coordination between the two facilities is not required to achieve significant benefits. The implementation of this concept can be done in two independent phases (i.e., adapt one ARTCC first, as in the Single Center – Independent Concept, and then add the second ARTCC) and can be considered as the first phase of a two phased approach leading to the Dual-Center – Dependent Concept.

As described in Section 6.4, this concept requires that two TMA systems be developed, one adapted for ZNY and one adapted for ZDC. Slave displays of these systems must be implemented within the PHL TMU and possibly for the non-adapted ARTCC TMU to facilitate coordination. Since TMA is only adapted for a single ARTCC, there does not need to be significant changes to the TMA architecture, functionality or data feeds. For the impact of this concept on the TMA functionality and adaptation, see Sections 8.0 and 9.0, respectively.

The main users of the TMA systems in this concept are the two ARTCC TMCs. Each ARTCC TMC will be responsible for developing and implementing flow restrictions for their facility, based upon their facility's acceptance rates, developed in accordance with the TRACON TMU. The independent operation of TMA at each facility will require "up front" coordination between the ARTCC and TRACON TMUs and potential adjusting of the various TMA parameters used to determine final meter fix times. The establishment of the TMA parameters would be the function of the TRACON TMU, in coordination with the two ARTCC facilities. These values would be determined very early in the operational day and would be based on the anticipated traffic, weather, runway in use, and any equipment or staffing anomalies. Each facility would have input into the establishment of these parameters, however, PHL is responsible for the final decisions for the airport values. Once the overall arrival rate for PHL is determined, the allocation of separate arrival rates for each facility, ZNY/ZDC, must be agreed upon. This coordination activity must continue through the operational day. When dynamic changes in traffic demand from each facility occur, the allocation of arrival rates between the facilities must also be modified. It is expected that with a little experience, the breakdown of acceptance rates between the facilities would stabilize based on the nominal rushes that occur regularly each day. Coordination would only be necessary for minor adjustments based on the inevitable variations that occur in actual demands based on actual arrivals.

Once the arrival rates for each facility are developed, the TMA in each facility would work on its portion of the overall traffic into PHL to meet its acceptance rate. The ARTCC TMCs in each ARTCC will be responsible for monitoring the system to identify when the predicted traffic load is expected to exceed that facility's portion of the PHL acceptance rates. Because each facility has just the data for its traffic entering PHL, it will be difficult for either ARTCC TMU or the TRACON TMU to get as accurate a picture of the threshold loading as if the data were combined. To compensate, buffers will most likely be added to the acceptance rates for both facilities to ensure there is enough flexibility to handle ties at the threshold. As predicted demand exceeds the acceptance rates for that facility, each ARTCC TMU will develop a metering program, with TMA, and implement it through the display of metering lists at the sectors. Since each TMU has complete authority over its own facility and metering times, TMA would function in each facility in a manner extremely similar to operations at ZFW today. The separation of the overall acceptance rate between the facilities is the only coordination necessary for successful operation of metering in the two facilities.

If the dynamic load of traffic changes significantly during a rush period, the three facilities could coordinate a change in the acceptance rates to meet the new demand. For example, if a rush is evenly distributed between ZNY and ZDC, the two facility arrival rates would be equal. If the ZDC traffic demand was reduced before the ZNY demand, the three facilities could coordinate to increase ZNY's rate (and reduce ZDC's rate) to remove the unnecessary restriction on ZNY traffic. The proposed configuration change functionality within TMA could be used to plan this change in advance, so the change occurs smoothly.

7.3 Scenarios

The following two sections describe the expected operation of TMA in the TRACON Concept (Section 7.3.1) and in the Dual-Center – Independent Concept (Section 7.3.2) for a traffic scenario that represents typical operations within PHL and the surrounding airspace. The scenario is a PHL morning rush under VFR conditions. The airport is utilizing runways 27R and 35 for arrivals, departing on 27L. The scenario begins with a push of Tower En Route traffic that precedes the main jet push. This scenario usually begins at approximately 8:30 AM each weekday morning. For both cases, the acceptance rate for runway 27R is 54 and runway 35 is unrestricted.

7.3.1 TRACON Concept Scenario

For this scenario, it is assumed that the PHL TRACON TMU requires two monitor displays for display of TMA data. One display shows the four timelines for BUNTS, MAZIE, TERRI, and VCN and runway threshold timelines for both 27R and 35. The other monitor displays load graphs set up for each arrival fix and threshold with load lines depicted based on TRACON traffic management coordinator (TTMC) preference. Both ARTCCs (ZNY and ZDC) will have a single monitor display in the TMU, displaying timelines for all four feeder (metering) fixes (BUNTS, MAZIE, TERRI, and VCN) with the ability to switch to load graph displays as desired. Airport configuration and acceptance rate data for TMA will be developed and input by the TRACON TMC based, upon the expected traffic and weather for that time period.

The normal morning traffic flow starts at approximately 8:30AM with Tower En Route arrivals beginning to enter the TRACON airspace at the predetermined Tower En Route hand off points and routings. For this scenario, it is assumed that these aircraft are not scheduled within the TMA system. Therefore, these aircraft will not be displayed on a TMA timeline. The PHL arrival controllers vector these aircraft to runway 27R or runway 35 whichever is most operationally advantageous at the time. The arrival traffic is light so there is no problem with traffic volume. If it were desired to schedule Tower En Route traffic (mainly to show interaction with the main jet flow later in the rush), this traffic would be originally scheduled to runway 35 (and displayed on that runway's timeline) and manually switched to runway 27R as desired.

At approximately 9:00AM arrival traffic begins to approach the four feeder fixes at BUNTS, MAZIE, TERRI, and VCN. For the most part, the first aircraft to arrive at the fixes are commuter aircraft and they are scheduled and vectored to the main arrival runway, 27R, because the Tower En Route arrival traffic is steady and utilizing runway 35. Since there should be no delay for these aircraft at this time (runway 27R is fairly under-utilized at the start), these commuters will land on runway 27R unless an operationally advantageous opportunity causes them to be vectored to 35. At this point, the traffic flow is steady and the runways are beginning to fill, but TMA indicates no need for restrictions.

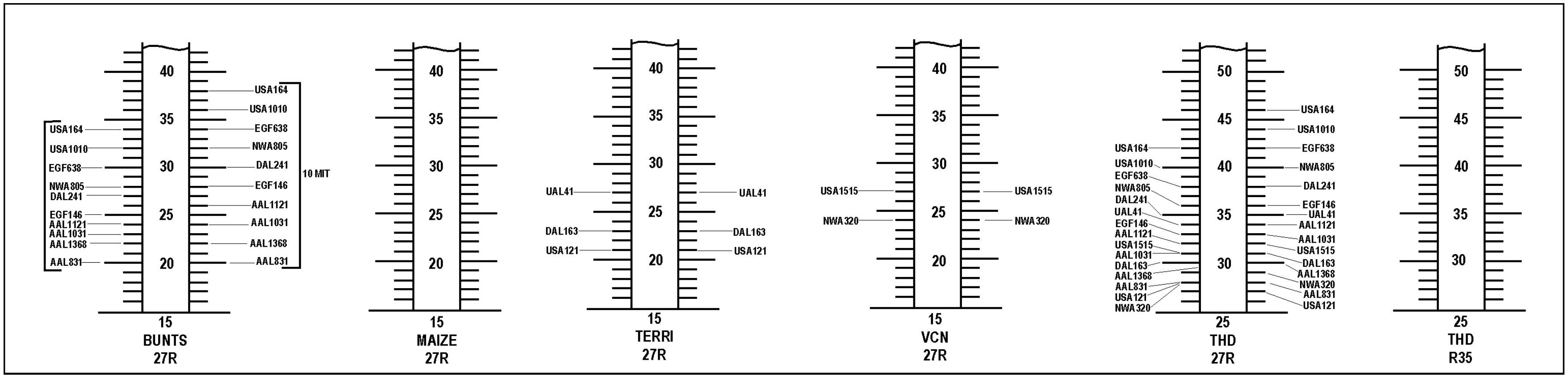
As the arrival push begins to increase with the arrival of the main jet traffic over the four feeder fixes, the Tower En Route traffic volume remains steady (to runway 35) and the bulk of the traffic from BUNTS, MAZIE, TERRI, and VCN is scheduled to runway 27R (jet traffic does not utilize runway 35 due to its short length). The TTMC continuously monitors the timelines and load graphs to determine when the predicted arrival rates will exceed the acceptance rate parameters set for runway 27R within TMA. Based on TMA estimated times of arrival, it is predicted that the demand on PHL will start to exceed the acceptance rate at 09:20 AM (see figure 7.3.1-1). The TMA timelines display that delays are required for the aircraft crossing BUNTS at that time.

In figure 7.3.1-1, the timeline is showing that the 10 aircraft predicted to cross BUNTS, the 3 aircraft crossing TERRI and the 2 aircraft crossing VCN between 09:20 and 09:35 will exceed the runway 27R acceptance rate for that time period (15 aircraft in a 15 minute period is equivalent to 60 aircraft an hour, which exceeds the acceptance rate of 54). TMA is displaying that an equivalent miles-in-trail of 10 over BUNTS for the 20 minutes between 09:20 and 09:40 will remove the excess demand (this delays two of the aircraft to cross BUNTS between 09:35 and 09:40).

The TTMC analyzes the aircraft crossing BUNTS and determines that 2 of the 10 are commuters and are capable of using runway 35. After estimating the Tower En Route load on runway 35 during the time when the two commuter aircraft are predicted to arrive at the airport, the TTMC determines that the two commuter aircraft would be able to be removed from the 27R pattern and fit into the pattern for runway 35. The TTMC then removes the two commuters from the 27R streamclass (by changing their runway assignment to 35) and determines that a restriction at BUNTS is no longer required (see Figure 7.3.1-2). The display of the two commuter aircraft on the runway 35 timeline is an excellent visual cue to remind the TTMC to coordinate this change of runway with the TRACON arrival controllers.

If the two commuters were not able to be removed from the runway 27R flow, then the TTMC would contact the ZNY TMU and alert the TMC that a MIT restriction of 10 n.mi. needs to be imposed over BUNTS from 09:20 through 09:40. If the ZNY TMU has a TMA slave display, then this TMC will be able to identify which specific aircraft are being affected. The ZNY TMC would then implement the restriction with the appropriate sector controllers within ZNY ARTCC. The ZNY TMC would also be able to coordinate the addition of MIT restrictions on ZOB handoffs to support ZNY in meeting the 10 MIT restriction for PHL.

The scenario as explained is an example of how the TMA will strategically improve the traffic flow to PHL, continue to keep pressure on the final approach courses and reduce delays for arrival aircraft.



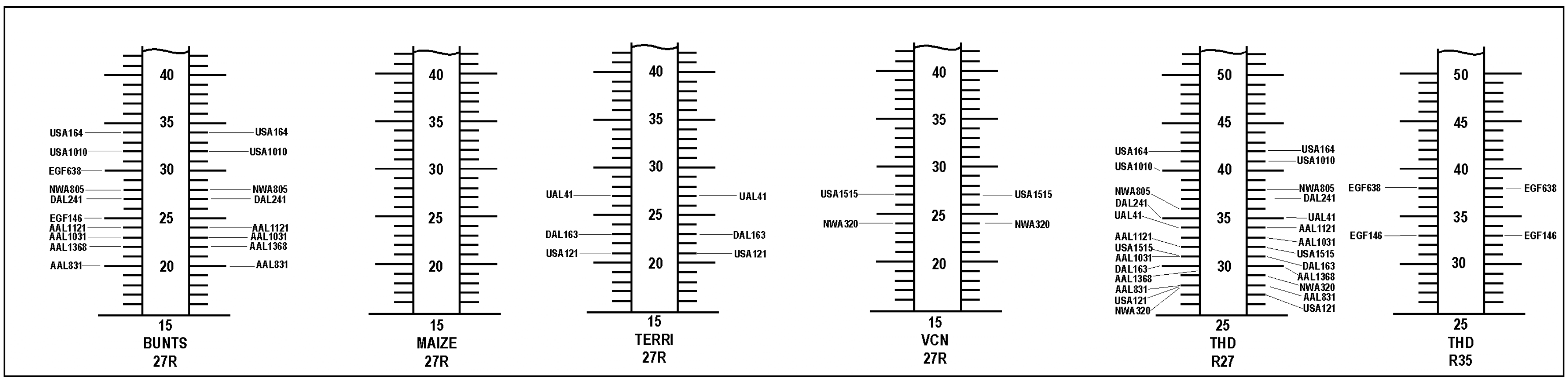


Figure 7.3.1-1 (top) and Figure 7.3.1-2 (bottom)

7.3.2 Dual-Center Independent Concept Scenario

For this scenario, it is assumed that the each ARTCC TMU requires two monitor displays for display of TMA data. One will be an active TMA display showing two timelines for the metering fixes within that ARTCC (e.g., BUNTS and MAZIE for ZNY, TERRI and VCN for ZDC), and possibly a third timeline with the threshold as a reference point. The other is a slave display showing timelines for the other ARTCC metering fixes (e.g., TERRI and VCN for ZNY, BUNTS and MAZIE for ZDC) and possibly a timeline with the threshold as a reference point. The threshold timelines for each ARTCC will not be integrated and therefore the ARTCC TMCs will need to "mold" the traffic picture mentally at the runway by referring to the two threshold timelines. The ARTCC TMCs will have the capability to switch over to display load graphs displaying arrival traffic and load line data for each arrival fix, as desired. In the TRACON TMU, two slave displays, one for ZDC and one for ZNY traffic will be available (similar to the ARTCC displays, but both will be slaves). Airport configuration and acceptance rate data for the two TMA systems will be developed by the TRACON TMC and input by each ARTCC TMC, based upon the expected traffic and weather for that time period. In this example, the 54 arrival rate for runway 27R will be divided into 34 for ZNY and 20 for ZDC. As described earlier, the acceptance rate data for each TMA system will be a portion of the overall PHL engineered acceptance rate, determined by agreement between the three facilities.

The normal morning traffic flow starts at approximately 8:30AM with Tower En Route arrivals beginning to enter the TRACON airspace at the predetermined Tower En Route hand off points and routings. For this scenario, it is assumed that these aircraft are not scheduled within the TMA system. Therefore, these aircraft will not be displayed on a TMA timeline. The PHL arrival controllers vector these aircraft to runway 27R or runway 35 whichever is most operationally advantageous at the time. The arrival traffic is light so there is no problem with traffic volume. If it were desired to schedule Tower En Route traffic (mainly to show interaction with the main jet flow later in the rush), this traffic would be originally scheduled to runway 35 (and displayed on that runway's timeline) and manually switched to runway 27R as desired. To this point there is no need for ARTCC (or TMA) involvement with the arrival flow.

At approximately 9:00AM arrival traffic begins to approach the four feeder fixes at BUNTS, MAZIE, TERRI, and VCN. For the most part, the first aircraft to arrive at the fixes are commuter aircraft and they are scheduled and vectored to the main arrival runway, 27R, because the Tower En Route arrival traffic is steady and utilizing runway 35. Since there should be no delay for these aircraft at this time (runway 27R is fairly under-utilized at the start), these commuters will land on runway 27R unless an operationally advantageous opportunity causes them to be vectored to 35. At this point, the traffic flow is steady and the runways are beginning to fill, but TMA indicates no need for restrictions.

As the arrival push begins to increase with the arrivals of the main jet traffic over the four feeder fixes, the Tower En Route traffic volume remains steady (to runway 35) and the bulk of the traffic from BUNTS, MAZIE, TERRI, and VCN is scheduled to runway 27R (jet traffic does not utilize runway 35 due to its short length). Both ARTCC TMCs continuously monitor the timelines and load graphs to determine when the predicted arrival rates will exceed the acceptance rate parameters set for runway 27R within TMA for his/her ARTCC. Based on TMA estimated times of arrival, it is predicted that the ZNY demand on PHL will start to exceed ZNY's acceptance rate at 09:20 AM (see figure 7.3.2-1). ZNY's TMA timelines display that delays are required for the aircraft crossing BUNTS at that time.

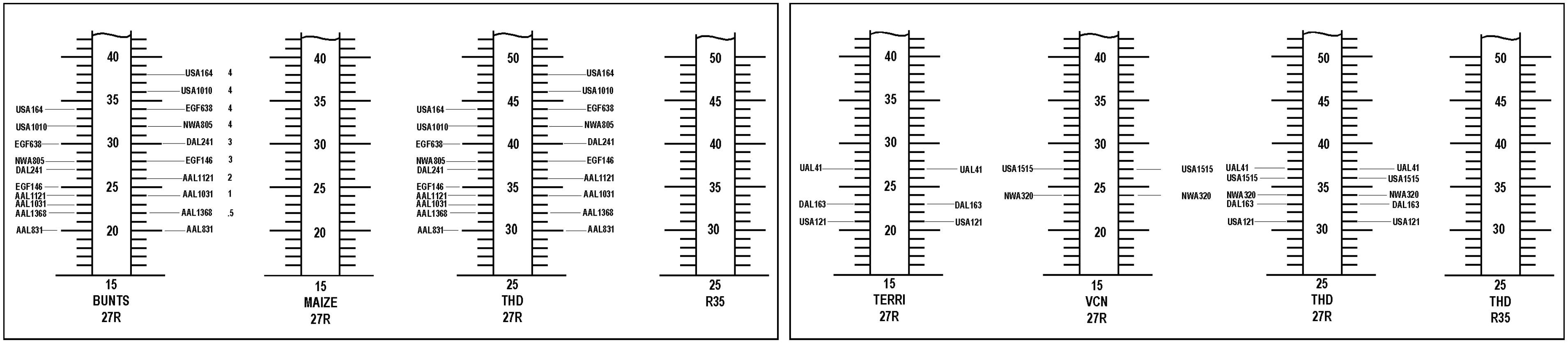
In figure 7.3.2-1, the timeline shows that the 10 aircraft predicted to cross BUNTS between 09:20 and 09:35 will exceed the ZNY portion of the runway 27R acceptance rate for that time period (10 aircraft in a 15 minute period is equivalent to 40 aircraft an hour, which exceeds the ZNY TRACON acceptance rate of 34). TMA is displaying delay values up to 4 minutes over BUNTS and that metering in ZNY for the 20 minutes between 09:20 and 09:40 will remove the excess demand.

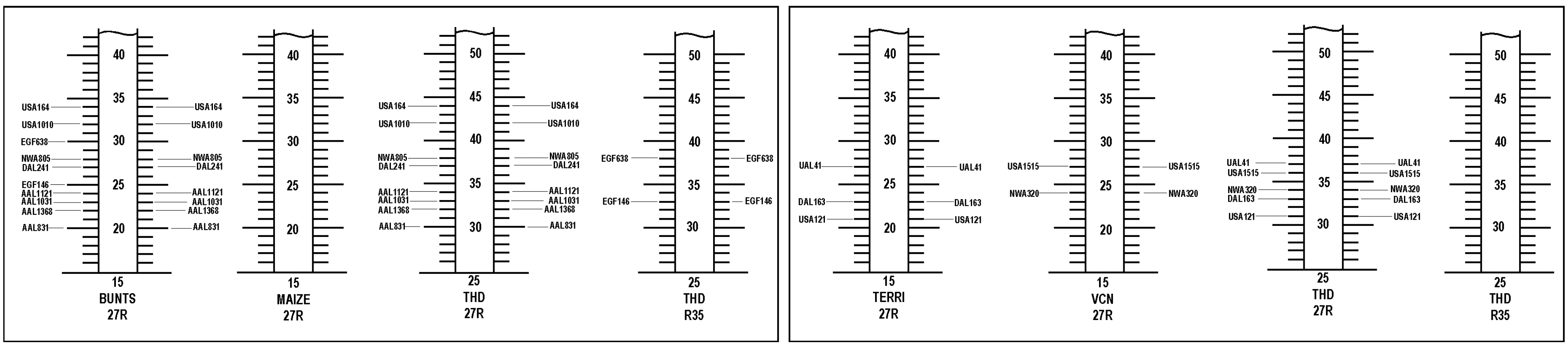
The ZNY TMC analyzes the aircraft crossing BUNTS and determines that 2 of the 10 are commuters. Based upon previous experience, the ZNY TMC knows that commuters can sometimes land on runway 35, if space is available, and can therefore be removed from the acceptance rate restriction for runway 27R. The ZNY TMC calls the TRACON TMC to advise him/her of the situation and asks whether the two commuters could fit into the pattern for runway 35. After reviewing the slave displays of TMA and estimating the Tower En Route load on runway 35 during the time when the two commuter aircraft are predicted to arrive at the airport, the TRACON TMC determines that the two commuter aircraft would be able to be removed from the 27R pattern and fit into the pattern for runway 35. The TRACON TMC informs the ARTCC TMC that the runway change is acceptable and that the ZNY TMC should implement the solution.

The ARTCC TMC then removes the two commuters from the 27R streamclass (by changing their runway assignment to runway 35). The modifications made to the schedule remove the need to delay any aircraft (see Figure 7.3.2-2), and the initiation of metering within ZNY is avoided. No further coordination is required by the ZNY TMC. The display of the two commuter aircraft on the ZNY slave display timeline for runway 35 is an excellent visual cue to remind the TRACON TMC to coordinate this change of runway with the TRACON arrival controllers. If the two commuters were not able to be removed from the runway 27R flow, then the ARTCC TMC will coordinate and implement the metering within ZNY ARTCC between 09:20 and 09:40.

Throughout this scenario, ZDC is unaffected and no coordination is necessary.

The scenario as explained is an example of how the TMA will strategically improve the traffic flow to PHL, continue to keep pressure on the final approach courses and reduce delays for arrival aircraft.





Figures 7.3.2-1 (top) and 7.3.2-2 (bottom)

8.0 Required Functional Enhancements to TMA

Though the selections of the two concepts presented in Section 7.0 were based upon maximizing operational benefits while minimizing operational and functional changes to TMA software and algorithms, both concepts require either some modifications to TMA functionality or changes in how existing functionality is used. Tables 8.1 and 8.2 in the following section present a summary of the modifications/conceptual changes in the use of TMA setup parameters and functionality for both the TRACON Concept and the Dual-Center - Independent Concept. Significant parameter/functionality changes are described in detail in these sections. The Traffic Management Advisor TMA Supervisor's Reference Manual (Release 5.3.1acft) was used as the definition of current TMA setup parameters and functionality.

Setup Parameter		***Impact of Concept***	
Name	**Panel**	**TRACON**	**Dual Center (Independent)**
Airport	F1	unchanged	unchanged
Configuration	F1	unchanged	coordination required*
Airport Acceptance Rate	F1	unchanged	coordination required*
Runway Flow Rates	F1	unchanged	coordination required*
Separation Matrix and Buffer	F1	unchanged	unchanged
TRACON Acceptance Rate	F1	unchanged	coordination required*
TRACON Delay	F1	unchanged*	unchanged*
Gate and Meter Fix Acceptance Rates	F1	unchanged	unchanged
Stream Class Settings	F1	unchanged	unchanged
Show Scheduling Functions	F1	unchanged	coordination as above
Load Graph Settings	F2	unchanged	unchanged*
Plot Settings (Load Graph)	F2	unchanged	unchanged
Current Display Format	F3	unchanged	unchanged
Proposed Flights	F4	unchanged*	unchanged*
Not On Timeline	F4	unchanged	unchanged
Traffic Count	F5	unchanged	unchanged
Delay Reporting Status	F6	unchanged	unchanged
Configuration Summary	F7	unchanged	unchanged
Popup Aux Data	F8	unchanged	unchanged
Timeline Setup	F9	additional data*	unchanged
Scheduling Options	Shift F10	additional	additional data*

		data*	
Flight Plan Readout	F11	unchanged	unchanged
Rush Alert Configuration	F12	unchanged	unchanged
Blocked Scheduled Broadcast Configuration	Shift F12	unchanged	unchanged

* Detailed comments below

Table 8.1. Impact of PHL Concepts on TMA Setup Parameters

Configuration:

The selection and changing of a configuration requires no modification in the TRACON Concept. The only conceptual difference is that this information will be input by the TMC within the TRACON, as opposed to being input by the TMC in the ARTCC.

In the Dual-Center Concept, the TMC in both ZNY and ZDC will enter the SAME configuration name and Flow Parameter setting within their independent TMA. The configuration parameters (and name) must be agreed upon by all three facilities prior to implementation within TMA. During operations, the three facilities will agree upon the desired configuration and the two ARTCC TMCs will setup the desired configuration within their own TMA. The use of consistent names between the facilities will ensure proper synchronization between the two independent TMA and provide a robust method for confirmation of synchronization. All three facilities will have access to the configuration name and other parameters for both TMA within the F7 (Configuration Summary) panel.

Airport Acceptance Rate (AAR):

The selection and changing of an AAR requires no modification in the TRACON Concept. The only conceptual difference is that this information will be input by the TMC within the TRACON, as opposed to being input by the TMCs in the ARTCCs.

In the Dual-Center Concept, individual AAR will be set for the ZNY and ZDC TMA. The selection of specific AAR for ZNY and ZDC will be agreed upon by all three facilities based upon historical data and refined during initial operation of TMA. It is expected that due to the repetitive nature of traffic flows, that static AAR will be developed for given configurations and/or characteristic rush periods (e.g., the early morning rush). Changes in AAR due to dynamic changes in a rush will be coordinated by the three facilities during operations.

Runway Flow Rates:

The selection and changing of runway acceptance rates and occupancy times requires no modification in the TRACON Concept. The only conceptual difference is that this information will be input by the TMC within the TRACON, as opposed to being input by the TMCs in the ARTCCs.

In the Dual-Center Concept, individual runway acceptance rates and occupancy times will be set for the ZNY and ZDC TMA. The selection of specific runway flow rates for ZNY and ZDC will be agreed upon by all three facilities based upon historical data and refined during initial operation of TMA. It is expected that due to the repetitive nature of traffic flows, that static runway flow rates will be developed for given configurations and/or characteristic rush periods (e.g., the early morning rush). Changes in runway flow rates due to dynamic changes in a rush will be coordinated by the three facilities during operations.

TRACON Acceptance Rate (TAR):

The selection and changing of a TAR requires no modification in the TRACON Concept. The only conceptual difference is that this information will be input by the TMC within the TRACON, as opposed to being input by the TMCs in the ARTCCs.

In the Dual-Center Concept, individual TAR will be set for the ZNY and ZDC TMA. The selection of specific TAR for ZNY and ZDC will be agreed upon by all three facilities based upon historical data and refined during initial operation of TMA. It is expected that due to the repetitive nature of traffic flows, that static TAR will be developed for given configurations and/or characteristic rush periods (e.g., the early morning rush). Changes in TAR due to dynamic changes in a rush will be coordinated by the three facilities during operations.

TRACON Delay*:*

The setting of a TRACON delay value is unchanged for the two new concepts, though it is not expected that the value of 240 seconds will be appropriate for the much smaller PHL TRACON.

Load Graph Settings:

For the Dual-Center Concept, the setting parameters initially available for load graphs is expected to be satisfactory, though it is anticipated that new parameters may be desirable to improve the use of load graphs. In this concept, the ZNY and the ZDC will be displayed on separate displays and information from the two ARTCCs will not be able to be combined on single graphs. This will be especially noticeable when threshold Reference Points are desired. To understand the total load on a runway, the data on two graphs will have to be visually combined.

Since this concept is assuming that the runway acceptance rate can be divided between the two ARTCCs, this limitation may not be significant. This makes the assumption that the load limit line on the desired runway can be set to the ZNY acceptance rate value for the ZNY TMA and independently the ZDC load limit line can be set to the ZDC acceptance rate value for the ZDC TMA. New settings may be desired if a TMC wants visual cues to improve their ability to coordinate values from one ARTCC graph to another.

Proposed Flights*:*

For satellite departures in either ZNY or ZDC, this functionality is not expected to be necessary for the TRACON Concept, since it is not required when running miles-in-trail restrictions. In the Dual Center Concept, the ZNY and ZDC TMUs will use this functionality as normal.

There is an issue with Tower En Route traffic that needs further clarification. Tower En Route traffic makes up a significant portion of the traffic into PHL, due to the close proximity of so many airports. This traffic generally precedes a jet rush over the metering fixes (commuters are coming in early to make connections with the jet departures) and is always routed to runway 17/35. The jet and turboprop traffic that arrives over the metering fixes is routed to 27R (typically), and turboprops from this stream are rerouted to runway 17/35 if an opportunity exists.

Since the Tower En Route traffic does not significantly mix with the traffic over the metering fixes, it is expected that an initial concept for TMA could be effective without the need to handle data for the Tower En Route traffic. For example, all traffic crossing the metering fixes could be scheduled to land on the main runway (27R), and a TMC could strategically pull turboprops out of this stream (by either changing the runway assignment or suspending scheduling for this aircraft) after coordinating a place on 17/35. A second method could be to put an extremely low acceptance rate on 17/35 for turboprops crossing one of the metering fixes.

Full TMA benefits would be anticipated if the Tower En Route traffic were included in TMA processing. In this case, they would be handled similarly to the TMA is being used in Southern California TRACON.

Timeline Setup*:*

For the TRACON Concept, the timeline will have to present “equivalent miles-in-trail” functionality display to support the generation of miles-in-trail (MIT) restrictions for each of the metering fixes. When equivalent MIT functionality is desired, TMA should display a bracket starting at the STA of the first aircraft to receive the MIT restriction and ending at the STA for the last aircraft to receive the restriction (see Figure 7.3.1-1). The equivalent MIT restriction should be displayed on the bracket. A bracket and associated MIT should be displayed for each advised restriction.

To support the definition of the equivalent MIT algorithm parameters (TRACON Concept), the following parameters should be added to the F9 setup panel:

- Minimum equivalent MIT
- Minimum interval

- Minimum number of aircraft within bracket

Scheduling Options:

For both concepts, the addition of ETMS data will be necessary to increase the scheduling time for aircraft entering ZNY from ZOB and crossing BUNTS, due to the short transit time from the ZOB/ZNY boundary to the ZNY/PHL boundary. A data option should be added to allow the use of ETMS data within this panel.

Functionality	***Impact of Concept***	
Name	**TRACON**	**Dual Center (Independent)**
Locate An Aircraft	unchanged	unchanged
Manual Rescheduling	unchanged*	unchanged*
Reschedule Aircraft	unchanged*	unchanged*
Broadcast	unchanged*	unchanged*
Runway Change	unchanged	unchanged
Allocate Runway	unchanged	unchanged
Metering Fix Change	unchanged*	unchanged*
Proposed Metering Fix	unchanged*	unchanged*
Suspend Scheduling	unchanged	unchanged
Resume Scheduling	unchanged	unchanged
Reset Aircraft	unchanged	unchanged
Priority Status	unchanged	unchanged
Find Slot	unchanged	unchanged
Planned Separation of Two Aircraft	unchanged	unchanged*
Blocked Intervals	unchanged	unchanged
Blocked Slots	unchanged	unchanged
Delay an Aircraft at a Satellite Airport	unchanged*	unchanged*
Ground Delay	unchanged*	unchanged*

* Detailed comments below

Table 8.2. Impact of PHL Concepts on TMA Functionality

Manual Rescheduling:

This functionality will work as normal for both concepts. In the TRACON Concept, it is not expected that this functionality will be used for the same purposes as it is used in ZFW today (e.g., to move an aircraft to an earlier time when a sector controller identifies the opportunity). The ability to manually change an aircraft’s scheduled time of arrival, though, is a basic functionality that should be available to the TRACON TMC to give flexibility in handling unexpected situations.

In the Dual-Center Concept, this functionality will only affect the schedule for the ARTCC that implements the manual schedule.

Reschedule Aircraft:

This functionality will work as normal for both concepts. In the TRACON Concept, any rescheduling of aircraft will be coordinated with the affected ARTCC TMU. In the Dual-Center Concept, this functionality will only affect the schedule for the ARTCC that implements the reschedule.

Broadcast:

In the Dual-Center Concept, each ARTCC TMU will be responsible for the broadcast of scheduled times to their sector controllers. This functionality will work as normal, but will be limited to information for a single ARTCC.

In the TRACON Concept, the broadcast functionality will not broadcast information to any sector controllers. The existing functionality will most likely be used, as currently developed, to indicate acceptance by the TRACON TMC of a new schedule. In this way, ARTCC TMCs will know that a new schedule has been "officially" accepted in TMA when the broadcast indicators (e.g., the "!" indicators in front of aircraft ID) are removed from the Traffic Management Advisor Graphical User interface (TGUI). Since no broadcasting to ARTCC sectors is required, the TMA can be run in the TRACON in "one-way" mode.

Metering Fix Change:

Functionally within TMA, changing a metering fix will function as normal. For the Dual-Center Concept, only metering fix changes within an ARTCC can be handled within TMA. To send an aircraft to a metering fix in the adjoining ARTCC, a flight plan amendment in the HOST will be required (with all the accompanying operational procedures). Once the flight plan amendment has been implemented, the aircraft will be removed from the original ARTCC TMA and will show up in the other ARTCC TMA.

In the TRACON Concept, metering fix changes between ARTCC metering fixes will be possible within TMA. Initially, this will probably be procedurally restricted unless a significant benefit can be achieved. The change within TMA will have to be coordinated with both ARTCCs.

Proposed Metering Fix:

This functionality is limited by the same restrictions as in the Metering Fix Change functionality. The trial planning of "gate balancing" between gates in different ARTCCs is not possible within the Dual Center concept. Since the sending of aircraft from ZNY to ZDC (or vice versa) is not common today, it is not expected that the loss of this functionality will significantly impact operations at PHL.

Planned Separation of Two Aircraft:

For the Dual-Center Concept, only the separation of two aircraft coming from the same ARTCC can be determined at the threshold. This restriction does not exist for the TRACON Concept.

Delay and Aircraft at a Satellite Airport:

See description for the *Proposed Flights* setup parameter.

Ground Delay:

See description for the *Proposed Flights* setup parameter

9.0 Adaptation Requirements

9.1 TRACON Concept

For the TRACON Concept to be successful, data from both ARTCC Host computers (ACES as well as input track and flight plan data) must be combined and coordinated for input into TMA. The architecture of TMA should be able to adequately handle the data from the two Host computers if they can be successfully merged.

At its core, TMA processing of information for scheduling of aircraft requires the aircraft's current state (track data) and a 3D path that the aircraft is going to fly. The path is generated by flight plan amendment data and knowledge of the airspace (in the form of ACES data). It may take a little bookkeeping effort to accomplish, but there should be no "show stoppers" in combining data from two ARTCCs into an equivalent, single "super" ARTCC. This should be roughly equivalent to the combination of aircraft and airspace data on separate sides of Dallas or Denver Center. The biggest trick will probably be finding a mutually agreeable "point of tangency" parameter to convert latitude/longitude data into X/Y data. Because the combined ZNY and ZDC airspace is no larger than ZFW or DEN airspace, a single point of tangency value should be achievable.

The most significant challenge is where (and how) to merge the track and flight plan data. There are three potential solutions to this problem:

1. Use the ZNY Host computer
2. Get separate feeds from ZNY and ZDC and merge in the radar daemon
3. Use ETMS

The ZNY Host computer is the Host for sending flight plan data to PHL. It contains data from both ZNY and ZDC to facilitate the handoffs from both ARTCCs. A detailed exploration for this as a solution to the data merging problem was not performed, but it is expected that all of the data needed from ZDC (e.g., track updates) is not passed to the ZNY Host. If there were enough data, this would be the obvious and simplest solution to the data merging problem. If not, then modifications to the Host system might be possible, but this would be costly and extremely time consuming.

If ZNY does not contain enough data on ZDC for TMA to operate, a second option is to get a Host connection from each Host computer and merge them within a radar daemon. This has a large benefit in that it would not require modification to either Host system and that any development would be internal to the NASA software development group. The negative side to this solution is that the ability to successfully coordinate the data would have to be explored and it is not known as to whether any “show stoppers” exist.

A third, and probably the most attractive solution, would be to utilize modified ETMS data. ETMS currently extracts and coordinates data from all Host computers across the country for display on Aircraft Situation Display (ASD) within facilities across the U.S. According to the Volpe Center (the organization that developed and runs the ETMS system), ETMS has access to all data from any given Host. Currently, ETMS is limited to 5 minute track updates (soon to be reduced to 1 minute updates). This limitation is due to the extremely large bandwidth requirements from receiving data from all Hosts across the country. Sources at the Volpe Center agreed that it would be possible to create a prototype system (similar to the ATMS system used to supply data to the Collaborative Decision Making Program) to feed a TMA prototype at PHL data that coordinates ZNY and ZDC track (and flight plan) data alone. Because of the reduced number of Hosts from normal ETMS operation (and the lack of a need for two-way connections since the TRACON Concept does not provide metering lists to a Host computer), all the data required for the TRACON concept for TMA could be delivered through this system.

The addition of normal ETMS data may be critical because of the short transit time for aircraft flying from Cleveland ARTCC (ZOB) to PHL over BUNTS. The adaptation for this data should at least follow the same process as is being done for ZFW. It may be possible, if the ETMS solution for merging the two Host data streams within TMA is utilized, that data from Cleveland’s Host computer could be added to the data from ZNY and ZDC to alleviate the need for a separate ETMS feed of Cleveland track data at the normal ETMS reduced update rate.

It is expected that suitable solutions to all adaptation problems are achievable within the desired time for development of a prototype system.

9.2 Dual-Center Concept

To successfully adapt TMA for the Dual-Center Concept only requires that TMA be adapted for both the ZNY and ZDC ARTCC independently. There are no known complexities to this adaptation other than the fact that some data (i.e., for aircraft not transitioning to PHL) should be filtered out at the radar daemon (or CTAS ISM process) level, if desired.

The use of ETMS data for the ZNY system may be critical because of the short transit time for aircraft flying from Cleveland ARTCC (ZOB) to PHL over BUNTS. The adaptation for this data should follow the same process as is being done for ZFW.

10.0 Required NAS Infrastructure Changes

10.1 Software and Hardware

For the Independent concepts, both Dual-Center and Single Center, TMA is adapted for only one ARTCC. This implies that data, both ACES and flightplan/track data, from only one ARTCC is required. Since this is exactly the same requirement as for TMA as implemented at ZFW, NAS software and hardware changes required for this concept should be exactly the same as those already developed for TMA at ZFW. This includes full two-way connection between TMA and the ARTCC Host computer to allow the display of TMA metering list data on sector controller displays.

Because of the short distance between the ZOB/ZNY and the ZNY/PHL boundaries, it is anticipated that ETMS data for ZOB arrivals to PHL will have to be utilized to improve the capability of TMA to schedule traffic over BUNTS. This development should follow the development used to develop the same capability for ZFW.

For the TRACON Concept, and the Dependent Center concepts as well, data is required from two ARTCCs simultaneously to create the equivalent of a “super” ARTCC containing both ZNY and ZDC within TMA. As described in the adaptation requirements section, one solution to this problem could involve modifications to the current Host/non-Host relationship between ZNY and ZDC for PHL. Currently, ZNY as the Host computer for PHL is responsible for sending appropriate ARTCC data (e.g., flight plans) to PHL. This includes passing through data from the ZDC Host, which is referred to as a non-Host with respect to PHL. From the standpoint of TMA data requirements (e.g., up to the minute track data), it is not expected (though a detailed analysis has not been performed) that enough ZDC Host data is passed to the ZNY Host. One solution for the TMA data requirements for the TRACON Concept could be to develop the connection between the ZDC and ZNY Hosts to allow arrival data from ZDC to also pass flight plans and other information required for TMA. Though not required for the TRACON Concept, the ARTCC concepts that use metering would require a two-way connection to both the Host (at ZNY) and the non-Host (at ZDC) systems. This would require development of the ZNY Host to “pass through” ZDC metering list information from TMA to the ZDC non-Host. As described in the adaptation requirements section, unless this “pass through” ability, both input and output to TMA, currently exists within the Host computer at ZNY, the use of direct connections with the two ARTCC Host computers or the use of a connection through a modified version of ETMS is considered more desirable.

Since TMA is considered a “standalone” system with respect to the NAS, other plans to upgrade existing hardware/software within the ARTCC and TRACON facilities is not expected to be impacted. This includes the upgrades to existing ARTSIIIA terminal automation system at PHL with the Standard Terminal Automation Replacement System (STARS) and the replacement of the en route automation systems and displays with the Display Replacement System (DSR).

10.2 Roles and Responsibility Changes

10.2.1 Philadelphia TRACON (PHL)

10.2.1.1 PHL Traffic Management Coordinator

The changes to this operational position will include an increased requirement to staff this position during any period where arrival traffic will reach levels high enough to bring the functionality of TMA into play. For the TRACON Concept, the role of the TRACON TMC will be greatly increased from that of today. The TMC will interact with TMA and become a significant player in the planning of PHL arrival traffic. As the TMCs become more familiar with the subtleties of the TMA tool, they will increasingly use opportunities to take advantage of TMA functionality. This will include reaching out to adjacent facilities and coordinating with them as much as 90 minutes in advance of an aircraft’s predicted TRACON boundary crossing time to make arrival flow adjustments to maximize the PHL arrival rate.

In all concepts, the PHL TMU will work more closely with the ZDC and ZNY TMUs simply because they will have a simultaneous presentation of data common to all three facilities. It is not important which TMC within a particular TMU takes an initiative to modify the traffic flow, as long as they are in communication and coordinate properly with each other. ATC has always been a cooperative effort and TMA lends itself to enhancing the ability of these three facilities to accomplish this cooperation in an informed atmosphere.

The PHL TRACON will have an array of TMA displays; i.e. time lines, load graphs, etc. The location and proximity of this equipment to the arrival radar controllers will have an impact on the ability of the TMCs to effectively interact with controllers and supervisors in the TRACON during heavy arrival traffic flows. The appropriate location of this equipment is typical of the kind of decisions that will be best made by the on-site teams.

The PHL TMU, in all of the concepts, will also be responsible for providing current and timely airport data essential for the setup of TMA. This includes, but is not limited to, airport/runway/TRACON acceptance rates, runway configuration, outages, NOTAMS, and other pertinent information required for the effective operation of TMA. The actual input of this data into the TMA system will either be accomplished by the TRACON TMC (as in the TRACON Concept) or by the ARTCC TMCs (as in the ARTCC concepts) as agreed upon by all three facilities in operational letters of agreement.

10.2.1.2 PHL Supervisor/Coordinator

The PHL TRACON supervisor, who often acts as a coordinator to assist the controllers during heavy traffic situations, will work with the TMC regarding operational air traffic control matters. They try to stick to staffing and other personnel matters. This should not be directly affected by the introduction of TMA. Local facility management policies are also not directly impacted by TMA.

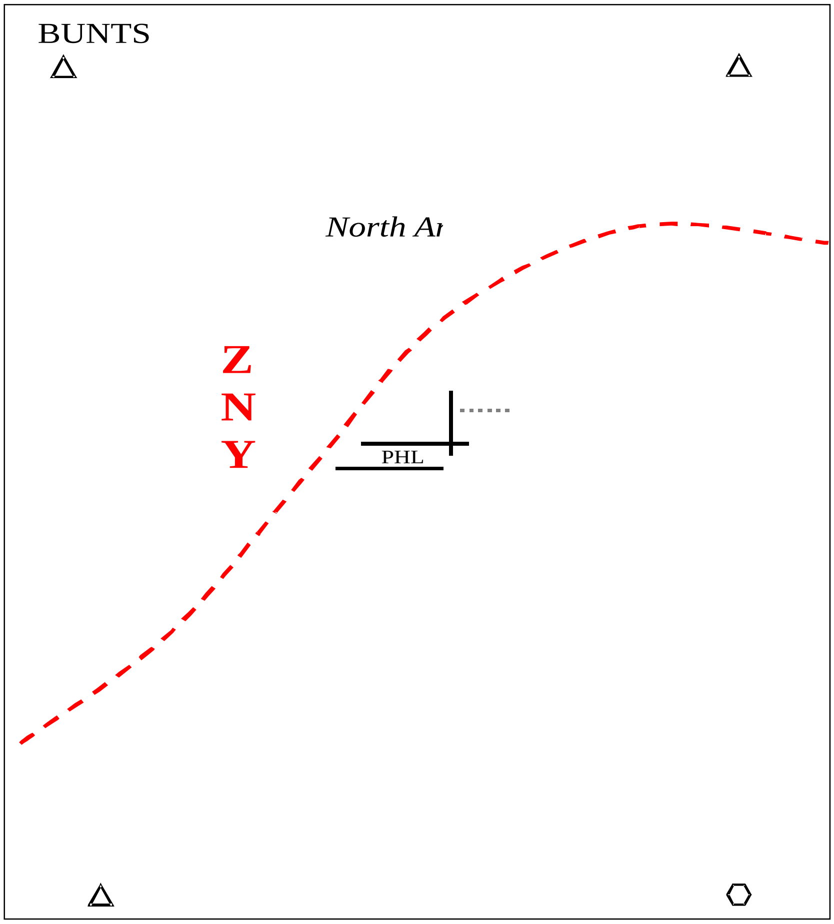


Figure 10.2.1-1: Philadelphia arrival position scheme

10.2.1.3 PHL Arrival South and Arrival North Controllers

Figure 10.2.1-1 displays the arrival position scheme for PHL TRACON. These controllers, who are some of the beneficiaries of a successful TMA operation, will not have to make any serious adjustments to their current operational procedures to accommodate TMA. They will continue to coordinate with adjacent sectors within PHL and in the ARTCCs and TRACONS outside of PHL airspace.

The interaction between the TRACON TMC and these controllers may increase slightly during modifications in the general flow to achieve capacity benefits. For example, if the TMC plans to pull an aircraft out of the main runway 9/27 stream to reduce the loading on this runway, the plan will have to be coordinated with the arrival controllers for implementation. This could increase the workload of these controllers. It is anticipated that the benefits accrued from TMA for the arrival controllers in terms of even flows and better terminal loading will more than offset that small burden.

10.2.1.4 PHL Arrival Final Controller

This control position will require no changes in its standard operating procedures (SOP). Any positive impacts on the operation of this position will be indirectly gained through the improvements in operation of the Arrival controllers.

10.2.2 New York and Washington ARTCCs

10.2.2.1 Traffic Management Coordinator

This en route operational function currently operates differently from the TRACON TMU in that it is responsible for traffic management in support of <u>all</u> the terminal facilities within the respective ARTCC boundaries (rather than just one TRACON). Because these responsibilities are so diverse and widespread, the TMCs are required to scan all the involved sector operations. They coordinate internally with supervisors and controllers and externally with adjacent facilities (some with a TMU and others with none). They also communicate and coordinate strategic traffic management activities with the FAA System Command Center in Herndon, Virginia. They are constantly briefed on weather systems and use that data in coordinating and planning with each of the affected parties.

In the TRACON concept, the change in operation for these TMCs will involve coordinating with the TMC at PHL in developing MIT restrictions that achieve the desired flow rate. This will probably not greatly increase their current workload, but actually change it from dealing with holding situations to working out a MIT program that will avoid holding. The hope is that the benefits of increased planning and avoided difficulties when PHL “closes the door” will far outweigh the workload increase due to more coordination.

In the Dual-Center – Independent Concept, the TMCs will be required to implement metering procedures within their ARTCC. Though the tool is expected to significantly improve their ability to plan and manage traffic, the workload associated with implementing metering is significant. Thankfully, the development of metering procedures at an ARTCC has been successfully implemented (e.g., at ZFW) and the experiences gained during this process will help to develop the required procedure at ZNY and ZDC.

For all concepts, Standard Operating Procedures will need to be developed and Letters of Agreement modified to incorporate the use of TMA and to give the TMCs the guidelines and authority to use TMA to it's fullest capability. Coordination procedures will need to be established between the TMUs at ZNY, ZDC, & PHL. Backup procedures must also be established in the event of TMA failure.

10.2.2.2 Supervisors

In the TRACON Concept, no significant changes are anticipated in the operation of these functional responsibilities. The coordination required to implement MIT restrictions based on TMA is not unlike the coordination functions currently employed by these supervisors.

For the Dual-Center – Independent Concept, these supervisors, like the TMCs and controllers, will need to be trained in metering procedures.

10.2.2.3 Controllers

In the TRACON Concept, no significant changes are anticipated in the operation of these functional responsibilities. The coordination required to implement MIT restrictions based on TMA is not unlike the coordination functions currently employed by these controllers.

In the Dual-Center – Independent Concept, the TMA generated metering lists will be displayed at the appropriate radar sectors and will provide the radar controller with the necessary information to achieve the required scheduled times of arrival. This will create a significant increase in workload for the controllers while assisting them in maintaining an efficient arrival rate for PHL.

The significant adjustment to be made by these controllers will be in dealing with the requirement to achieve the aircraft scheduled times at the metering fixes. This has been a routine technique in ZFW for over twenty years, but it is an entirely new procedure to the controllers in both ZDC and ZNY. With proper familiarization and training, it is expected that they will adjust quickly. The facility will determine the method of training, i.e., classroom, simulation laboratory, and/or "on the job" training. They will benefit by drawing on the ZFW experiences.

10.2.2.4 Automation Staff/Airways Facilities Staff

It is anticipated that the cooperation of these staffs will be an important part of the introduction of TMA to these facilities. An evolutionary process typical of the installation of any new automation function into a FAA air traffic facility will dictate the level of this cooperation. The initial testing and demonstration periods will be for an indefinite period and will also have the benefit of the ZFW/DFW experience.

Deliverable Item 4

Work Plan and Staffing Requirements

11.0 Introduction

Whether it is for the development of a system prototype or for the national deployment of a field ready system, the introduction of a new automation system into an air traffic control facility is a complex event that requires careful planning and coordination. When the introduction of this system simultaneously impacts, directly or indirectly, the operations of three (or more) facilities, the complexity is greatly increased. To effectively implement a prototype TMA system for PHL requires both a sound technical (research) approach for the development of the system concept and a sound strategy for coordinating with the facilities during the various stages of development.

The following document is a description of a work plan and staffing requirements for the initial development of TMA within the PHL, ZDC, and ZNY environments. The work plan outlines the steps required for development, simulation, field testing and evaluation of an initial prototype TMA system. Since NASA is intimately aware of the staffing requirements for developing a TMA system prototype through initial (and advanced) operations at an air traffic facility, the staffing requirements section below focuses on FAA participation in this process. Specifically, the additional FAA personnel (i.e., particular organizations within the FAA), above those required for the development of a TMA prototype within a single facility (e.g., ZFW), are described.

In Deliverable Item 3, multiple candidate operational concepts were presented. Since all of these concepts have at least a minimal impact on all three facilities, the team members and work plan presented are considered to be valid for all concepts. The level of participation of different team members and the magnitude of different events within the work plan are expected to vary from concept to concept.

12.0 Work Plan

The following is an outline for the required steps in the development of a TMA prototype system for PHL. The work plan outline provides steps only through initial field evaluations of TMA (i.e., Proof of Concept evaluations). The direction of TMA development for PHL will have to be re-evaluated at that time to decide whether the development should be transitioned into the FAA for full system implementation. Decisions regarding future developments will be made as FAA and NASA teams continue to work together at these three facilities.

12.1 Concept Selection

Based on the candidate concepts provided in Deliverable Item 3, NASA should select a concept for development. The selection of this concept should be based upon many factors, including technical challenge of software development, political realities, and the experience of seasoned TMA developers. The concept that provides the best balance between these many factors should be selected. Benefits studies may be conducted to support the selection process.

12.2 Benefits Analysis

If a benefits study was not performed during the Concept Selection phase, a study should be done immediately after the selection of a concept. A thorough analysis of the potential benefits associated with the system concept, starting with those identified within Deliverable Item 3, should be performed. The benefits analysis should focus on quantitatively determining the magnitude of potential benefits to evaluate whether full prototype development is warranted. Based upon the results of the benefits analysis, it may be determined that a different system concept should be pursued.

12.3 Requirements Definition

Once a concept has been selected and the potential benefits quantified, a detailed definition of the requirements for that concept must be completed. The goal of the requirements definition phase is to define the specific problems that the TMA functionality will solve in order to achieve the identified benefits (i.e., definition of the benefit mechanisms). Based on the problems to be solved, specific TMA functionality will also be defined.

The requirements definition phase begins with a series of briefings by NASA with FAA Headquarters, the Eastern Region, and upper management from the three facilities (ZNY, ZDC, and PHL). The purpose of these briefings will be to orient all concerned parties with the development goals of the selected TMA concept and to present the anticipated benefits. These briefings will setup FAA support for the overall project and for the upcoming development phases.

Once support for the project has been achieved, working visits should be performed with the traffic management coordinators and controllers from the facilities directly impacted by the implementation of TMA. Visits should also be made to ZFW to gain better insight into the actual operation of TMA within this environment. During these facility visits and through subsequent conversations with these ultimate users of the TMA functionality, the baseline system requirements for the prototype will be developed.

12.4 Software Development

Based on the initial requirements for TMA functionality developed within the requirements definition phase, a working prototype for TMA should be developed. This development should include the creation/modification of TMA functionality, site adaptation for the appropriate facilities, as well as coordinating the development of NAS changes to support the prototype implementation. If ETMS data is required, then the appropriate coordination with the Volpe Center should be performed. Any software development required to enable simulation of the TMA prototype in a laboratory environment should also be completed during this phase.

12.5 Development Simulations

Concept development simulations are an important part of the development of any ATC automation prototype. This is the phase in which controllers and TMCs (not necessarily from ZNY, ZDC or PHL) can be brought in to help the researchers iterate on the system design. By running these low fidelity simulations, different ideas for meeting the requirements can be quickly evaluated and design decisions made. The result of this phase is a solid prototype that achieves the required functional requirements.

12.6 Procedures Development

In coordination with all impacted facilities, procedures need to be developed for both ATC and TMA operations. These new procedures should minimize the impact on and be as compatible as possible with the current ATC procedures at these facilities. The development of the final procedures will be an ongoing process and changes to procedures will have to coincide with the changes in the system functionality (as iteration on the system design continues).

12.7 Evaluation Simulations – System Design Team (SDT)

At this stage of the prototype's development, a cadre of TMCs, controllers and employee organization representatives (i.e., Union representatives) from the facilities directly impacted by the implementation of TMA should be established by the FAA. This team, as members of the System Design Team (SDT), will represent the interests of these facilities for the duration of the prototype development.

In preparation for field testing, evaluation simulations involving the SDT need to be performed. The purpose of these simulations is to refine the system concept and procedures with the ultimate users of the system to ensure successful operation in the field. Iteration on the system design (including resultant software modifications) and procedures must be performed until the SDT approves the prototype for field "shadow" testing.

12.8 Field "Shadow" Testing

In support of ultimate field testing and evaluation, the SDT-approved prototype should be implemented at the field sites for "shadow" testing. Shadow testing involves running the prototype at the facilities, but not implementing the operational solutions developed by TMA. For example, TMA could be implemented within a TMU (which TMU depends on the selected concept) and both researchers and members of the SDT cadre will evaluate the resultant schedules and restrictions proposed by TMA. Because the system is being evaluated in shadow mode, the TMA proposed resolutions will be evaluated, but not implemented (i.e., operations will not be affected). These evaluations, consisting of comparisons between the TMA solutions and actual operations, will identify problems with TMA effectiveness in the field and give researchers ideas for improving TMA performance.

Iteration on the system design (including resultant software modifications) and procedures must be performed until the SDT approves the prototype for field evaluation. This may include more evaluation simulations and continued shadow testing.

12.9 Field (Operational) Evaluations

The final step for the development of the TMA prototype is to perform the initial field evaluations to confirm the system's operational benefits. To perform the operational evaluations, the final prototype must be implemented within the facilities. The facility personnel of all impacted facilities must be trained in the use of the system and in the supporting procedures. A field research team must develop an evaluation plan, complete with data to be collected and the analyses to be performed upon completion of the testing.

Operational evaluations are usually planned as a series of evaluations with gradually increasing impact on the facility. For example, the first tests will most likely involve shadow testing to confirm that the TMCs are comfortable with the use of TMA. This could be followed by a test where metering or MIT restrictions are added to only a single metering fix or just a single ARTCC for a single rush period. The ultimate goal of this series of evaluations will determine the ultimate extent of TMA impact on the facilities to be evaluated.

13.0 Required FAA Participation

As in the development of TMA for ZFW, the successful coordination with the appropriate staff within the FAA is critical for the ultimate acceptance of a TMA prototype for PHL. Unfortunately, the ability to deal with just a single facility, as in the ZFW case, does not hold for PHL. The necessity to develop a system that impacts operations in all three facilities requires coordination between the FAA facilities, not just between the facilities and NASA

The need for coordination between multiple FAA facilities requires the involvement of FAA organizations outside of the facilities themselves. For example, the FAA Eastern Regional Office must be included in the initial orientation briefings. Operations specialists (at least one for PHL and one for the ARTCCs) will be assigned by the Regional Office to participate in all meetings between researchers and facility staff to ensure that the Region stays informed of the development progress. It is not expected that these specialists will have input on the desired operational impacts of TMA, but they will ensure that proper protocol is maintained within the FAA. Similarly, it is desired, though not required, that representatives from FAA Headquarters be present at initial orientation briefings.

Ultimately, the facilities will decide which of their staff will participate in the actual development of the system. The following is a list of organizations within the facilities that should be required to have at least some representation during the development of TMA.

PHL TRACON:
- Traffic management
- Facility training
- Facility operations and procedures
- Union representatives
- Automation (consulted on hardware/software installation impacts)

ZDC and ZNY ARTCC:
- Traffic management
- Facility training
- Facility operations and procedures
- Union representatives
- Automation (consulted on hardware/software installation impacts)